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PREMIUM FARM AND CROPS, NEW JERSEY.

MESSRS. WILLIAM PARRY, David B. Coles, and Barclay White, Committee of the Burlington County (N. J.) Agricultural Society, on Farms, Farm Buildings, Crops, and Reclaimed land, have submitted a report which concludes as follows:

The next and last farm visited was that of Pierre Lorillard's stock farm, near Jobstown, embracing about 1,100 acres of land, and comprising every convenience and requirement of a complete farm. The mansion is a handsome three-storied semi-Gothic building; near by is the coach-house, with accommodations for 24 horses, and the farm stables, with accommodations for 40 horses. In the center of the yard belonging to this establishment is an enormous food-bin capable of holding 9,000 bushels of grain at a time, and from which the food is drawn by shoots near the bottom. A broad and well-kept road leads from the mansion to the farm buildings, cattle yards, and a barn holding 400 tons of hay.

The stock kept here numbers about 1,200 head, as follows, viz., 300 horses, 300 cattle, 400 hogs, and 200 sheep. To prepare food for this large number requires a steam engine of 20 horse power, which runs five mills for grinding feed, shelling corn, cutting stalks and coarse fodder, and steaming the food in several large vats, from which the cooked food is taken in box cars which run on railways between the long range of cattle stalls where the Ayrshires, Jerseys, and Durhams are fed, each animal being marked through the ear with a strip of tin stamped with its number to correspond with the number in the herd record made at the time of its birth, so that the pedigree can readily be traced through sire and dam to its proper source. Another railway leads through the front of a long range of hog pens, 320 feet long by 18 feet wide, each pen having a yard paved with brick, 11 by 14 feet between the eating department and the open yard, leading to a trough of water running through the lower end of each yard, and in all 340 feet in length. The system of ventilation and drainage is so perfect and complete that there is no unpleasant smell or offensive odor to be detected, and the whole family of Suffolks, Essex, Berkshires, and Jersey Reds seem to enjoy their situation in perfect health and comfort.

There are four horse barns, 100 feet square on the outside, located distant from each other; the stalls open to the yard inside, which is lowest in the middle, where the sewer is placed to carry off the drainage under the ground. In the brood mare stables there are comfortable stables for 100 horses; the colt stables surround a circular track, where the colts can be exercised under shelter, one-eighth of a mile in circumference. A much larger barn is now being constructed than any yet completed, requiring 560,000 feet of lumber. The building is 343 by 100 feet, eaves posts 30 feet, inner box 28 feet, two wings 100 by 123 feet each; in the center there is 98 by 95 feet, supported by truss work, nearly all to be covered with glass; three cisterns 25 feet in diameter by 16 feet deep, three apartments in each, the middle filled with charcoal, through which the water is filtered before being drawn for use. But it is in vain to attempt to describe the grandeur of these magnificent edifices in the few moments devoted to them.

For the best arranged and most convenient set of farm buildings, the premium of $10 is awarded to Pierre Lorillard.

There have been laid on this farm fifty-one miles of under-draining and nine miles of open ditches, mostly discharging into the Ananicken Creek, a branch of the Assiscunk, which passes through the farm, which have reclaimed what was a few years since worthless swamp and bog, but is now beautiful meadow, thickly set with fine grass and rich pasture, and is the most successful experiment in reclaiming marshy land shown to the committee, and for which they award the premium of $10.

For the most profitably cultivated crop, the profits of which shall exceed $100 per acre, they award the premium of $10 to D. E. Howatt, farmer for P. Lorillard, for 6¾ acres of carrots, yielding by estimate (after pulling a few) 400 bushels per acre, making 2,700 bushels, which, at 40 cents per bushel, is $1,080; expense of seed, drilling, hoeing, cultivating, thinning, and six per cent. interest on the land, rated at $150 per acre, $212; leaving net profit on 6¾ acres, $868.

The attention of the committee was called to a field of 35 acres of good corn recently cut and stacked up, and the ground (a sandy loam) was then being seeded with wheat. They estimated the crop at 50 bushels per acre, making 1,750 bushels, which, at 50 cents per bushel, gives $875; the whole cost of plowing, planting, and cultivating, rating the teams at $2.50 per day, laboring men $1.13 per day, boys 75 cents, amounting in all to $242, which, taken from the value of the crop, leaves a profit of $633 on 35 acres, being an average of $18 per acre.

They thought the above crop worthy of notice, as showing that farming when properly managed will pay, even in these dull, hard times.

Beautiful driveways, arched, graveled, smooth, and firm as a good turnpike road, lead to the different departments, buildings, and inclosures, and are lined with elegant fences made of the best material; pickets and slats are largely of locust, posts six to seven feet high, all painted or coated with tar; they are clean, straight, erect, and free from any foul growth, and for which the premium of $10 is awarded to P. Lorillard for the best and cleanest kept fences on a farm of not less than 100 acres.

The premium offered by the society for the best and most profitably cultivated farm of not less than 50 acres is not disposed of, as the committee are not able to arrive at the immense value of the hundreds of thoroughbreds annually produced here, the record of some of which are of world-wide fame, but, as far as their knowledge extends, they can say that this establishment is the largest, best, and most conveniently arranged in all its departments for the purposes intended to be found anywhere.

ASH OF THE MISTLETOE COMPARED WITH THAT OF THE WOOD ON WHICH IT GROWS.

GRANDEAU and Boulton have communicated to the Paris Academy, as a portion of the results of their exhaustive investigation of the mistletoe, a comparative statement of the chemical composition of the radicles of various specimens of mistletoe taken from poplar, fir, and acacia trees, and of the branches upon which they grew. It was found that, although the composition of the ash of the mistletoe radicles varied with the species of tree from which they were taken, it was also essentially different from that of the ash of the branches themselves. The mistletoe contained much more potash and phosphoric acid than the trees on which they grew, and far less lime. The difference was not so marked as regards the chlorine, sulphuric acid, and silica. The mistletoe, therefore, seems to grow upon the trees much as plants in a soil, by selecting from the sap in varying proportions the elements necessary for its growth. One of the most remarkable facts in this connection is that the various specimens of mistletoe collected from different genera of trees show as little resemblance in composition among themselves as they do in regard to the wood on which they grow.

TURF BREAD FOR HORSES.—Biering having noticed that horses were disposed to nip at turf, to scour the gums, and that turf contained a considerable amount of nitrogen, made a bread of 200 pounds of corn and rye flour, 300 pounds of turf meal and 5 pounds of salt, which was eaten with avidity by the horses. By taking less turf meal, say ⅓ or even ¼, a very economical feed may be made, on which horses may be kept exclusively, according to his experience.

THE MILK TREE.

OUR engravings represent that remarkable curiosity of the vegetable world known as the milk tree (*Broscimum galactodendron*), with its leaves and fruit, the two latter half size, as studied by the celebrated naturalist, M. Boussingault.

The *Broscimum galactodendron*, popularly called by the natives of Venezuela the milk tree, belongs to the family of the *artocarpeas*, which also includes the bread-fruit tree of the Molucca Islands and Londa.

The trunk of the milk tree attains a height of from sixty-five to ninety-five feet, and when tapped it yields an abundant white viscous liquid which apparently possesses the qualities of animal milk.

This tree is found in all parts of tropical America, but is more frequently met with in Venezuela, where, says Boussingault, I enjoyed the vegetable milk during a period of a month, mixed with coffee or chocolate. He also states that during the war of independence in that country he several times saw platoons of soldiers going off to the mountains to tap the trunks of the galactodendron and fill their little jugs with the precious liquid, which is thicker than cow's milk, has a slightly acid reaction, and soon turns sour if left exposed to the air.

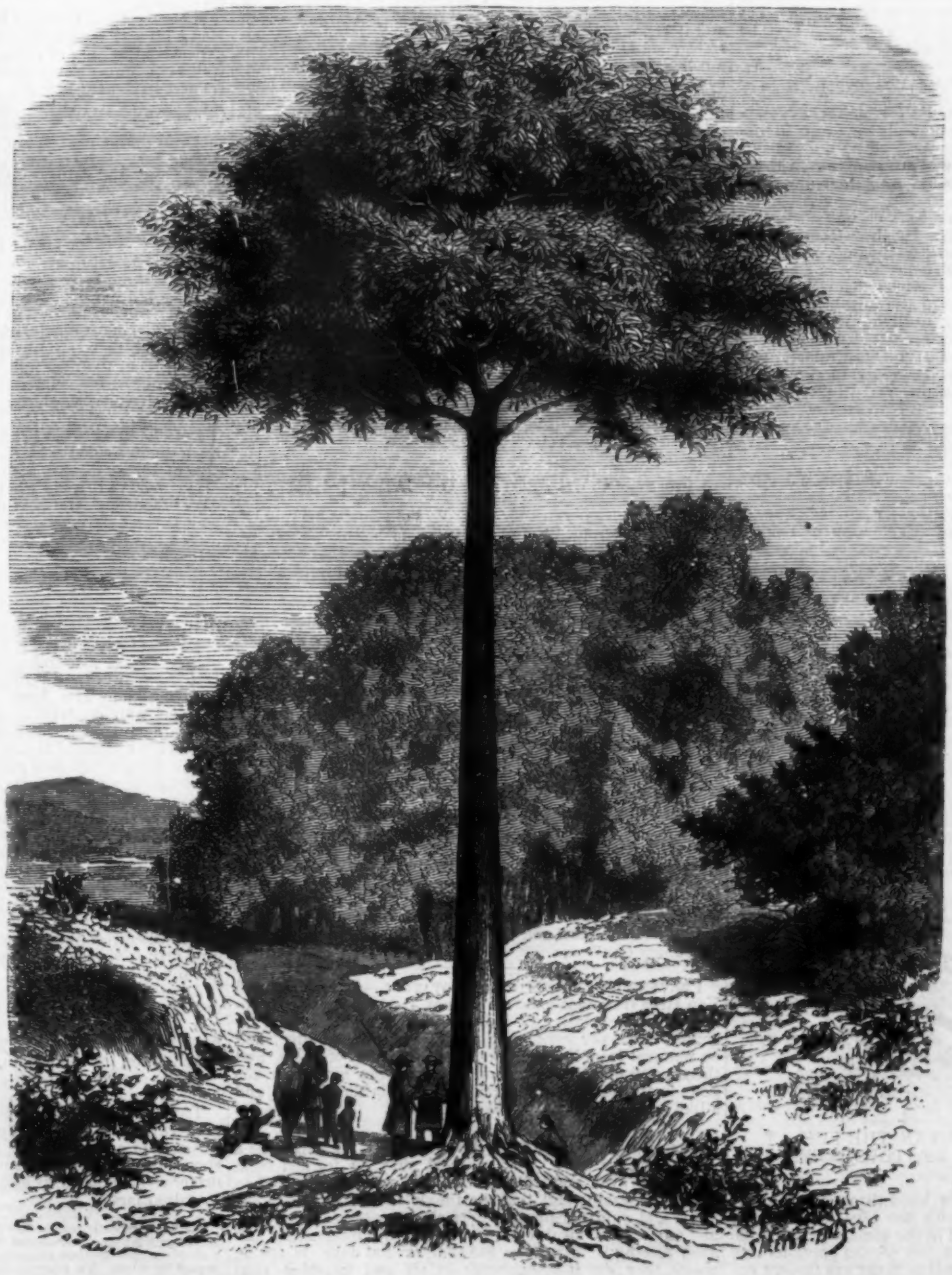


FIG. 1.—THE MILK TREE OF VENEZUELA.

FIG. 2.—LEAVES AND FRUIT OF THE MILK TREE. (HALF SIZE.)

A chemical analysis made by M. Boussingault reveals the presence of four groups of constituents, namely: a greasy substance, something like beeswax, which melts at 50°; a nitrogenous substance resembling vegetable fibrine; a saccharine substance; and finally, salts of potash, soda, and magnesia, chiefly in the form of phosphates.

At the French Exhibition of 1878 several flasks containing vegetable milk were exhibited, sent by the government of Venezuela.

M. Boussingault believes that the tree might be acclimated in Cuba, and that its cultivation there would have the advantages of a humidity not to be attained everywhere. In the opinion of this naturalist its introduction would be a valuable acquisition, not so much on account of the milk which the tree yields, which in reality does not compete with or equal that of animals as a popular food supply, but because of the enormous quantity of wax which may be extracted from the juice which it yields.

SIGNS OF THE QUALITY OF TIMBER OF CONIFEROUS TREES.

DR. SCHUBERT, of Bonn, gives the following tests for the quality of the timber of coniferous trees. Trees, especially pine, grown upon elevated locations, are superior to those from low and swampy grounds, as they are harder and more solid, and also have less tendency to rot. A clear sound emitted when a tree is struck with a hammer on a portion of the south side from which the bark has been removed, is indicative of soundness; and a hollow, dead sound, of a sickly tree. Gray elevations and reddish depressions in the bark are also marks of a sound tree; and whitish elevations and gray depressions, of the reverse. In the felled log excellence is manifested by reddish annual-rings, with pale interstices, whilst grayish rings with white, soft, crooked interstices, show that the tree was dead. The most reliable test of the quality of a log, however, is its ability to propagate sound; when the ear is placed upon one end, light taps on the other end should be distinctly heard.

DESTRUCTION OF GRASS, WEEDS, ETC.

ADLUNG recommends, as the cheapest and most effective agent for destroying grass, the so-called earth lye, a troublesome, worthless waste product of the potash industry at Stassfurt. It is essentially a saturated solution of magnesium chloride, containing a small amount of potassium chloride, magnesium sulphate, and common salt. The magnesium chloride is very poisonous to the roots of plants, and yet, on account of its ready solubility, it sinks so rapidly into the subsoil that by careful employment of it the adjoining vegetation remains unaffected. Tin cans can be used with it, and a single repetition suffices to eradicate the grass. A concentrated solution of kieserit, an impure magnesium sulphate, is almost as effective. This is also an abundant waste product at Stassfurt, and is brought into the market in rectangular blocks, at a low price. It requires warm water for its solution, which takes place slowly.

HARVESTING CARROTS.

THE season is now approaching for harvesting the carrot crop in many portions of the country, and we give the following simple mode for performing the work in a systematic manner for moderate plantations:

Take a good steel spade and loosen the roots along the first

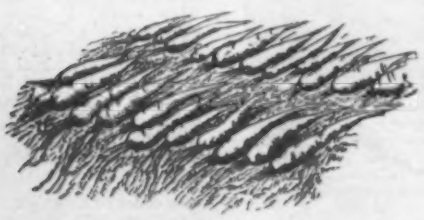


FIG. 1.—MODE OF DRYING IN THE SUN AT HARVESTING—ROOTS UP, TOPS DOWN.

row, and grasping the tops in one hand throw them about three feet back from the row with the tops toward you, shaking the roots well. Proceed in the same way with the next row, placing the roots on the top of the previous row (Fig. 1). Proceed in this way until as many are thrown out as can be secured the same day. The tops on which each row rests keep them from the ground and they dry rapidly; the earth is easily removed and the tops readily cut. This mode of drying is adapted to harvesting with the plow.

For preservation in winter, if there is no cellar, dig a shallow trench of any desired length, about three feet wide and eight or ten inches deep, where there is a perfect underdrainage. Place the roots here, heaping them up evenly like a two-sided steep roof. Cover them thickly with straw, so that when packed it may be nine inches to a foot thick, according to the latitude and winters. Cover this with three or four inches of earth beaten smooth (Fig. 2). The carrots will keep much better with plenty of straw and but little earth than under more earth and less straw. Make air-holes with a crowbar for each four or five feet of length, and when winter comes plug these with straw wisps.

A cellar is more convenient, accessible in winter, and attended with less labor. A house cellar is usually too warm, and if kept as neat as every good farmer wishes, ought not to be encumbered with cattle feed. Every barn should have a cellar under it; the sills will be more durable, and the only cost is excavation and walls. A cellar large enough to hold five thousand bushels need not cost over $200 to dig and build walls—or at the rate of four cents per bushel once for all time. Filled with roots, it would supply sixty cattle for five months with a peck each night and morning. Such a supply, in connection with dry fodder, would contribute

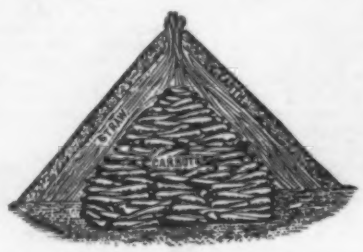


FIG. 2.—CROSS SECTION OF CARROT HEAP.

greatly to their health and thrift. The bottom should be paved and covered with water-lime cement, so that the earth which drops from the roots may be easily and neatly swept out. A root cellar should be kept in perfect order, and no filth or decaying vegetables ever allowed in it a day. It should have windows on opposite sides, and free ventilation allowed whenever the weather will admit. If the thermometer is not much below freezing, let the wind blow through, and lessen the current as the frost increases. The more uniformly cool the roots are kept the better and fresher will be their condition. Many would be surprised at the amount of air which might be admitted with safety. If the tight plank floor above is insufficient to exclude frost during the severest weather, a foot of straw over the tops of the roots will be an additional protection.

When barn cellars are large and hold many thousand bushels of roots, the ventilation will be imperfect unless a sparred floor is made a few inches above the cement bottom. It may be made of scantling of any convenient size, with inch spaces between. The passages between the bins for receiving the roots should be in the direction of the prevailing winds, so as to effect a free circulation—the wind being made to blow under the sparred floor. Without free ventilation both the roots and the timbers of the barn will decay. —*Country Gentleman.*

PREVENTION OF ROTTING OF POTATOES.—Drs. Nohl and Van Hees state that potatoes are not liable to rot in keeping, if immersed for half an hour, sound and unsound together, in a 1 per cent. solution of chloride of lime, and on removal from it in a 1 per cent. solution of soda, and then rinsed in pure water, and dried in the air. For 250 pounds of potatoes but ½ a pound of chloride of lime, and a like amount of soda would be required.

UTILIZATION OF FROZEN POTATOES.—It is stated, as a result of experience, that a meal may be formed from frozen, or even spoiled potatoes, that will keep as well as that from grain; and that the inhabitants of the more elevated and colder regions of Peru allow potatoes to freeze, and separate the meal formed from the skins by treading, and after placing it in nets or bags for several days, in spring water, they dry it by exposure to air and sunshine, thus producing a meal which is used by them for all kinds of food.

PRACTICAL NOTES ON LOCOMOTIVE ENGINE DRIVING.*

By MICHAEL REYNOLDS.

THERE is no royal road to the lever of a locomotive engine. Promotion is really and of necessity a matter of toil. Before a man can take charge of a locomotive engine, to work a train and keep time, it is imperative that he should have *more* than a knowledge of his engine.

The foot-plate is the only place where that knowledge can be acquired, for there only can a man learn the ways in which it is possible for an engine and train to go wrong. Every failure is a deviation from what should have been perfect success, and whatever contributes to lessen the probability of a failure must have a beneficial advantage. So engine men were at the beginning, and are now, as a rule, reared with the locomotive. It is found necessary that they should enter upon this branch of instruction young, whilst the mind is elastic and capable of receiving the most durable impressions.

A man may be a first-rate mechanic, he may have built engines, and have read all the published books on locomotive engines, and yet he is not capable of taking charge of a locomotive under steam, moving at the rate of 88 feet a second. Whilst an engine is under steam with a train keeping time, everything seen, heard, felt, and smelt, in connection with it and the train, is capable of conveying ideas to the driver. On the foot-plate the eye is taught or rather trained to distinguish colors at a distance; the ear learns to detect the slightest variation in the four beats of the two cylinders. It in time learns to detect the daily wear of a piston ring or a slide valve, and not only that, the mind is trained to look for the results of such wear and tear. As the ring or the valve loses its true and full value, there is an increase of blowing through of the steam, which acts upon the fuel, and increases the quantity and the size of the ashes in the smoke box. On the foot-plate the human frame learns to decide what oscillations and pitchings of the engine are due to a defective spring, and what are due to a defective permanent way. The nose becomes, from experience acquired under all kinds of circumstances, very sensitive, so that it can distinguish the rising of fire from waste carelessly left by the cleaner about the engine, from a fire originating from friction.

It is only under steam at high speed with a train that a locomotive engine man has the advantage of a stationary engine man.

On railways there are "coral reefs" and sandbanks. There are traps of all kinds; trap points, trap sidings, and gullets. These are put in for the public safety, and intended to trap a train—man, engine, and carriages. Should the engine and train come along in charge of an engine man who imperfectly knows the road, he is safe to be trapped.

Sometimes this trapping is very serious as regards expense. Many railway companies could show the public some very expensive trapping of engine and trains. I do not refer to trains containing passengers. The drivers in charge of passengers have been in many instances in some ugly traps in their earlier days, but having served some years on the goods trains, they become wise and precautionary, which qualifies them for taking charge of the more responsible part of the traffic.

The rank and value of every locomotive engine man is exactly in proportion to the labor and study he has bestowed on railway traps.

These are everywhere, even in the coal, in the tender, in the tube, and in the smoke box. When a man is trapped, no matter how, when, or where, he asks himself at once the question if anybody else has been served the same. If he satisfies himself his is an exceptional case, the man is not so much to be blamed; but if an engine man goes and does what others have done before him, and been fined for or discharged, he is, strictly speaking, to blame.

Well then, the rank and value of a locomotive engine man depends upon his acquaintance with matters purely incidental to railway working. Has he the hidden rocks upon his chart?

Does he know what has wrecked engines and trains? If he does not he drives by chance. Of all places in the world, chance has no locality upon a railway.

Locomotive driving when of first class quality is good to-day, to-morrow, and next day, and all the year round, that is, it is constantly good—true.

And why? Because it is based upon certain rules and principles.

A driver who keeps his eyes rolling and his mind active, seeks out the cause of every failure, and comparing them with his own experience, soon finds out how to obtain a salutary lesson. Now there are certain rules and principles about locomotive driving which, if they are observed, enable an engine man to keep time without cutting too deeply into the coal heap. Without such rules and principles all is uncertain. The hand trembles upon the regulator, the eye watches with painful anxiety the needle of the pressure gauge, and the driver, through looking into a white fire, is for a moment struck with color blindness. *Nothing* of this occurs with first class engine driving.

The rules and principles to which I am about to refer have proved themselves correct a thousand times over, and they have the property of relieving the mind of the driver from painful anxiety. Moreover, and beyond, they give the same results under all possible circumstances. They are not right to-day, and wrong the next day; not right with Derbyshire coal, and upside down with Welsh coal. Not right with one class of engine, and all astray with another. Not right with ten coaches, and wrong with twenty. In a word, when recognized and acted upon they enable an engine man to keep time, to travel with perfect ease, and to finish with success.

As soon as an engine man arrives on duty he examines his engine; there are few men but what do so; but hundreds of men have failed soon after the examination, from causes too numerous to mention, and which showed that the subsequent examination proved nothing.

Let us see how an engine should be examined properly before joining the train.

The driver arrives on duty and steps up on to the foot-plate, where he is generally supposed to be at least three-quarters of an hour before train time. The first thing he should do *is to know* what water there is in the boiler. Many drivers rest satisfied by looking at the gauge glass and not by actual fact.

* A paper recently read before the London Association. The President, Mr. Joseph Newton, introduced Mr. Michael Reynolds as one of the best authorities upon matters connected with locomotives. The gentleman had passed his whole life amongst engines, and as a practical man he had gone through every stage of locomotive engineering, and might, therefore, be considered a fit person to instruct others on the subject.—*Fireman Engineer and Draughtsman.*

It is only by actually opening the gauge cocks that a man can be positive as to what water is in the boiler. He should try all the gauge cocks on the boiler, and satisfy himself that they are all in working order; this is very important.

I have in my mind's eye a case in which two men's lives and two very valuable hunters, were lost *instantly* through a gauge glass cock not working—not having been worked daily, which it should be.

The driver in the case I am about to refer to was about to sight the distant signal of a station, but before he could see the signal light the gauge glass broke, and the steam and water required to be shut off. He attempted to do so and shut the water off, but the steam he could not, for the plug was fast; meanwhile he was going probably 88 feet per second, and being so much engaged with the water gauge, both he and his fireman missed the signals which were against them, and in all probability they were trying to shut a plug—only a small thing—when they were dashed into two horse boxes and some wagons. Two valuable lives sacrificed by not thinking what great disasters can arise from very *simple* accidents! The next thing for a driver to notice after the water, is the steam in the boiler when he takes possession of the engine. There have been engine men who came on duty three-quarters of an hour before train time, who at starting time found the engine would not move for want of steam. This was for want of a proper systematical method of overhauling an engine. If things are done by chance at haphazard, the result must be unsatisfactory. If a man chooses to examine loosely, or by halves, or anyhow, the penalty is astonishing to a man, but if he thinks seriously about the matter it is not.

When examining an engine it is a good rule to remember where others have failed and come to grief—what gave way. It is astonishing what little failures have done in the way of upsetting the ordinary working of a large traffic, not to mention the inconvenience suffered by passengers. More engines have failed through split pins and cotters working out than anything else in the motion. It is, therefore, requisite to act with caution *where* most men have failed, and to examine all things, on the principle that what is liable to fail is worth being overhauled thoroughly.

Now how should we examine an engine before she leaves the shed? The engine should be fixed with both big ends below the center of shark or crank axle, so that each part can be properly examined without moving the engine. The examination should be conducted systematically all round and underneath the engine, until the engine man arrives at the point where he commenced. He should commence on his own side of the engine at the trailing axle box and spring of engine, and examine all the spring and spring pins, until having gone round the engine he again reaches his own side of the engine. Whilst this examination is going on it is wise, I think, to remember *where* others have failed and *what* has brought them to grief, because an engine man's fame depends upon how closely he has inspected his engine before joining his train.

This examination I have just referred to is very important, and more so after the engine man has booked repairs to his engine. It has occurred and there is no reason why it should not occur again, that fitters have left their calipers in the feed pipe, left the right or left hand pump ram down after examining the piston of an engine cottered to a crosshead; they have left files in the steam chest after the cylinder faces have been faced up. This shows examination over the pit is not sufficient to secure successful driving, and it proves examination over a shed pit is only a part of a good beginning. Many an engine man has examined well—without examining on a system—who has failed on a train through a pump not working, either the suction, pump, or the top clack having been omitted by the fitter when examining the pump. Between the shed and the train a first class engine man puts his engine through certain performances, calculated to detect in time any deficiency in its action; for it is far better to find your engine defective between the shed and the train than to find it out on the road. When an engine has been undergoing repairs between trips particular inspection is necessary. Chapters could be written to prove that many things have been found out over a pit which had they escaped notice must have led to a vexatious failure.

The old saying, "that a good beginning insures a good finish," is indeed particularly applicable to preparing a locomotive engine for its trip, but doubly so as regards the fire. After the driver has found the true level of the water in the boiler, and the pressure of steam on his arrival, he should examine the fire. Firemen, as a rule, arrive before the drivers, and make up the fire in some instances before the engine man arrives; it is, therefore, very necessary for engine men coming on duty after the fireman has made up the fire to examine such fires. Unless the fire is properly constructed and well burnt through at the commencement of the trip, however clever an engine man may be, he will have a hard matter to keep time, especially if he should have a side wind and a heavy train. The *fire* at the start *must be right*. On some of the English express trains the average speed is 50 miles an hour, and in order to keep time the engines must run at some parts of the road 70 to 80 miles an hour. I have traveled at 82 miles an hour, and then arrived only to time. On long trips, say over 100 miles without stopping, the fireman should make up the fire, with Welsh coal, 1½ to 2 hours before train time. With Shipley or Derbyshire coal, it should be broken up into pieces the size of a brick, say, and watered well. But before the coal is put into the fire box there is a most important point in a fireman's duties to be observed, and that is, the fire bars should be protected either by chalk or sand, or fire bricks, from the effects of the fire, which will burn them if left totally exposed; moreover, a few broken fire bricks scattered fore and aft of the grate bars of a locomotive engine will probably prevent the coals falling out, and exclude the cold air from coming in. In making up a Welsh coal fire—and Welsh is chiefly used on this side of the Tweed—after the grate has received a coating of fire brick or chalk, the coals should be placed round the fire box, and not placed in a haphazard manner anywhere. Some firemen shovel the coals—that is all. And when you have said that, you have described their system. When the coals are placed round the fire box close against the heating surface, they must have the most effective effect. The heating substance is close to the requirements. The *best of the coals* should be placed in the fire box *in making up a starting fire*. There is nothing like having a good foundation. When a fire is made up of Welsh coal—good lumps placed round the box—it expands very much by the heat, and reminds an observer of a cauliflower plant. Hard coal or what is known as Shipley, Langley Mill, or Booth coal, does not swell so much, but it requires very nice treatment. Hard coal, such as I have mentioned (Shipley, Langley Mill, or Booth), has been put into the fire boxes or bank engines and remained there for fires until it was coked, and such engines have been after waiting for hours attached to pilot trains, and then at the finish of the trip the coals remaining have had all the appearance of coke. On this account many engine men using hard coal with tight dampers prefer to get it into the fire box in good time before starting—an hour before train time.

So much for the fire. The oiling is generally done by the driver on the outside of the engine, and the fireman does what is necessary underneath. The siphons which contain plug trimmings can be filled up at any time, as the swing of the machinery is necessary to cause the oil to lubricate. With tail trimmings it is different. The worsted ends being in the oil, they lubricate either stationary or in motion. The causes of heating when it leads to a failure is upon all railways a matter for serious investigating. No one on a railway likes to see good time keeping better than a general manager. He is, of course, responsible for all that takes place either in the locomotive or traffic department. The causes of heating are many. For instance, the worsted may be too tight in the first place, and it may become too tight through glutinous matter, such as resin or India-rubber, which is dissolved in some oils. The cotton may be too slack, siphoning all the oil away before the supply can be renewed. The cotton may be choked with tallow, which blocks up the tubes of the cotton, and this latter cause is more often the source of the mischief than anything else, and would not occur for obvious reasons if each driver was properly acquainted with capillary attraction.

If we look over the list of engine failures we shall find more engines hooking off their trains through having hot bearings than from any other cause, and apart from siphoning there are causes which produce the effect. If a keep to an axle box is bearing on the journal it will produce friction underneath the journal, and being deprived of lubrication, very soon causes a journal to fire. Then some brasses may be too light endwise, and not having sufficient lateral play to allow of a film of oil to separate the metals. And again, a bearing may have too much weight upon it; and lastly, a bearing may have too much bearing.

The history of locomotive failures is very instructive, for at least two-thirds of them occur through preventable causes which should have been prevented, and would have been prevented had the engine men systematically and thoroughly examined their engines over and off the pit before joining the train. In the charge of one driver an engine will run its daily trips and give the best of satisfaction, but when it is placed in the hands of another engine man she is always in trouble, not leaving the rails, but warming either in the motion or the axles, or by split pins coming out, or a big end siphon top slacking back, and thereby losing the oil which was intended for lubrication.

Examination before leaving the shed, and after doing so before joining the train, is very essential; but the constant cause of successful driving is close observation.

A philosopher hath said, A frequent similar effect argueth a constant cause. What, then, is the constant cause of successful locomotive driving, in so far as it applies to the engine under steam attached to a train?

The great and most important question to a driver is, Can I obtain steam? If I can I can run. Now, to obtain steam for a long run without putting any extra strain on the driver's mind is to make up a fire not too deep or too thick for the load on the piston. The shape of a fire that will make steam when all others fill will be concave; and besides making steam, with a little attention it will not clinker. The greatest evil is having too deep a fire. The exhaust steam from the cylinder has then not sufficient power to bring the air out of the ash pan through the grate openings into the furnace, and the dross in the fuel runs through the coals into the bars, whereas if the blast could have penetrated the fire its temperature would have been raised, and the dross literally consumed.

When the fire is concave it is much thinner in the center, and the body of the coals rests against the walls of the fire box, which is the superior portion of the heating surface. A fire made on this principle is true, and never deceived either driver or fireman. A few vigorous beats, and there are signs of a fire being all right, provided it does not hang together, which Welsh coal very often does. But if the engine is shy of steam and does answer the "thrashing," with regulator wide open and lever full over for a minute, then the best thing is, in the first place, to get a shovelful of small coals and scatter them over the top of the "stupid" fire; but chiefly along the sides, back, and front of the box, and the effect will be that some portion of the small coals will fall into the holes through which the fire box is drawing air. When the shovel of small coals has no effect the dart should be thrust into the center of the fire to open it if close, or to close it if burnt hollow, but on short trips, provided an engine man could see his way clear to keep time and keep his boiler safe, he may run for miles with a saving of fuel, for in time the action of the blast and the vibration of the engine will bring the fire round.

We are now under steam with a train, say. With a proper fire not too deep for the load on the piston a few puffs of steam will set incandescent coals into a fierce flame, and steam will be maintained. On our fast express trains running long distances without stopping the needle of the pressure gauge must point to a full boiler of steam exactly, nothing more or less; if the steam is allowed to waste at the safety valve it will tell upon the fuel, and if the steam is allowed to drop it will tell against the time sheet. Scarcely any locomotives in England have any great margin of reserved power. We have locomotives of the very best build and design, but they frequently have their work so cut out that an engine man requires to superintend them with great caution or they will surely round on him. It is only under certain conditions that they will stand "thrashing" to their work, and when that becomes a necessity the mode of firing becomes a great feature—a most important feature. To fire properly on fast expresses the fireman should command his work without fatigue, turning on his heels from tender to fire box and from fire box to tender. The shovel should be handled as though it were too hot to hold; every shovelful of coal should have its billet, and be delivered as clean as shot. The shovel should not enter the fire box, but stop dead on the fire door ring. There is, however, one shovelful required under the door, and the shovel *must* enter the box to land the coals against the back plate of the fire box.

The first shovelful—just what will lie on the shovel nicely—should be put in the left-hand corner. When the knees and the body follow the shovel about the foot plate firing becomes fatiguing; it should be done by the muscles acting through the arms. The second shovelful should be put in the right-hand corner of fire box, the third shovelful in the right-hand back corner, the fourth in the left-hand back corner, the fifth under the brick arch close to the tube plate, the sixth under the door. It is seen that such a fire is made close to the plates, and in actual contact with the heating surface, and that the center is self-feeding, the blast and the shocks of the road causing the lumps to fall from the sides into it. By this means the center is composed of the finest quality of the coals, free from dirt, and open so that the air can enter without interruption in the center, and mingling with the burning coals becomes heated and enters the tube at a very high temperature, doing them no harm. Further, the fire box is cold air proof. So long as air can be obtained through the grate in the center no clinkers will form, as the abundant supply of air is capable of consuming all the earthy matter contained in coal.

Similar coals have been delivered to two different drivers having the same class of engines, working the same day over the same metals with equal average loads, and the results have been very different; while one complained that they made clinkers, and was half afraid they would "suck some one in," the other pronounced them to be of fair average quality. The one driver put the coals in the center of the grate, but the other fired round the box after the manner already explained. It is a fact that some drivers run for weeks and never need to clean a fire. At the termination of the trip what clinkers they have they rake back under the door.

Next to the question of how to fire follows one of equal importance, viz., *when to fire*. On long trips, to effect a saving of fuel, the sooner the first round of coals is put on after starting the better, as it will prevent the fire, which is generally well burnt through, from passing away into the tube and raising steam too rapidly.

The best and the most favorable moment for opening the fire door to get some coals in is just as the steam is lifting the safety valves; by doing so the steam is slightly checked, which saves both water and fuel. Some drivers run twenty or even thirty miles before they start firing.

The interval between the start and each round of firing is regulated by the weight of the train, the state of the weather, and the time allowed to run the train, together with the quality of the coal; but however much these may vary, one thing will remain constant and certain, and that is, the fire, to maintain its efficiency, must retain its concave shape throughout the trip. The coals require to be put into the very place they are intended for when picked up by the shovel, and they should not be dropped in at the door and allowed to "wander."

The secret how to obtain and hold a respectable position on the coal saving list is, fire with few coals, and often round the box.

Notwithstanding the different plans which have been invented to effect the perfect combustion of smoke, the best plan is to employ a willing and persevering fireman, who puts both heart and soul into the work. The shovel is seldom out of his hands after he has commenced to fire until he finds he has sufficient in the box to finish the trip with. The practice, however, is in many cases to fire heavily, and by so doing the temperature of the furnace is suddenly reduced, and then leaking takes place. When to fire: Locomotive firing should be done with the steam on.

What an unsightly thing it is to see an engine entering a station with the driver at the break, the blower hissing loud, and the fireman shoveling coals on the fire! Undoubtedly this is not in accordance with first-class practice. In preference to the above, when firing is required it should be done away from stations and signals, and some two or three miles before the regulator is going to be closed, so that air can have an opportunity of getting through the fresh coals, and thereby assisting to keep down the smoke without much use of the jet.

When firing is done with the steam on the driver can give his eye for a moment to the fireman's actions, and see that every lump of coal finds its proper billet, and when the train enters the station both are attending to their respective duties. When the firing is done with the steam on the coals do not choke up the grate through which the iron steed draws his breath, the foot plate is kept free from smoke and sulphur, and the blower can also be dispensed with. When firing on long runs the most favorable spots and gradients for working the shovel should be selected and habitually used. The grand aim of first-class firemen is to keep the boiler at an even temperature from the start to the finish, up hill and down dale. To do this—and it is accomplished every day—the opportunity for opening the fire door should be seized. For instance, it should be opened the moment steam commences to waste from the safety valves; and this occurs frequently freely where little notice is taken of it, and that is when ascending an incline, when the fire door can be opened just to check the steam. The fire door should never be opened to check the steam, as it is best controlled by the dampers. When the wind is blowing hard advantage is taken of the cuttings and places where the line is well protected by the trees to prevent the coals being carried off the shovel. To avoid a choked fire—that is, one so thick as to prevent air entering the fire box through the grate openings—two things should be kept in mind. The back corners should be well filled up, and the fire should taper toward the tube plate. Firing, when done by the shovel alone, is one of the strongest evidences we can find in connection with a fireman's duties, of a man working his mind as well as his muscles, and whether on goods or passenger engines, the value and rank of every man will be in proportion to the mental labor exerted with each manual task.

While the engine is running the train the regulator should never be shut to pull the link up. The practice, especially an engine having a worn motion and play in the driving journal, is liable to break an engine down. It also inflicts a severe tensile strain upon the couplings, and is apt, when the steam is suddenly put on, to part the train.

It is a remarkable fact that engine men who habitually close the regulator to notch their engines up come to grief nine times out of ten while in the act of doing so. The answer to the question, "Where did this occur?" has been answered again and again by different men with the same reply. Just starting away from the station their piston rods have snapped off from solid material; piston heads have, even of brass, been bent by suddenly turning the steam into them.

The distance traversed from the station before commencing to expand steam depends upon the load, gradient, weather, and time allowed to run the trip in; but although circumstances will alter cases, yet there is one thing in connection with part of a locomotive engine man's duties that will remain constant, no matter what engine he has, and that is, after the train has attained a pretty good speed, the reversing lever should be used to notch up by degrees, and not pulled up almost out of gear at once. A few clear beats at the start not only prove whether the fitter has lined the

big end brasses up so that the piston head strikes the cylinder cover, but they prove also whether the fireman has put the coals on so that the fire box is air tight. To get away well without lifting the water out of the boiler into the cylinder is a very desirable attainment, because half a pint of boiling water will as effectually wash the lubrication off the face of the valves and cylinder as it will the grease off plates and dishes.

Priming in most instances is either due to the fault of the driver or fireman; but to avoid priming it is necessary to carry the water at one particular height which experience decides is the best.

Engines are worked by engine men three different ways: one driver, indifferent to the elasticity of the steam as a power, does not insist on the fireman keeping the steam up to the full boiler pressure, which is, say, 140 lb. to the square inch; he gets along and keeps time with the regulator open and the reversing lever in the third or fourth notch, allowing the steam to follow the piston some considerable part of the stroke. Driver B likes a boiler full of steam, 140 lb., but works his engine chiefly with the regulator—that is, wire draws the steam. Another driver works his engine with the regulator open, and expands the steam by cutting it off as early as possible, and sometimes, with a moderate load, the steam is released very little above the atmospheric pressure.

To run swift and important trains three things must be thoroughly combined in the experience of the engine man, and they are, knowledge of the signals, knowledge of the gradients, and knowledge of the traffic.

The greater part of every driver's time upon the footplate is occupied in attending to the signals, and until he is familiar with their relative position to the gradients, junctions, and stations over and through which he has to run, he cannot approach them voluntarily and at sufficient speed to keep time. Many of our express engines are only equal to a certain number of coaches, and when an engine is just loaded, if a minute or two is lost it cannot be fetched up again; therefore when an engine man has to "dig into" it is very necessary for him to know the road thoroughly. The weather in all instances has to be studied. In misty weather the rails are slippery, and the engine requires very close attention. In foggy weather the signals require close attention. Some signals, owing to their position, cannot be sighted well, but such signals can frequently be seen across country. While one engine man is running timidly into a curve and ready to act with caution should the signal be on, another has caught it in his eye a couple of miles off, and dashes into the curve at full speed.

Knowledge of the engine signals and gradients is worthy of every attention, but there is a different kind of knowledge necessary, and that is a knowledge of the traffic.

A few years ago a goods train with two engines attached was proceeding south at midnight. After it had passed the driver of a fast express going north a thought struck him that for two engines the roll or sound of the train going by him was unusually short. He stepped over to the fireman's side of the footplate to see if there were tail lights on the last vehicle, but owing to the curve and speed he could not see. He, however, knowing what goods they were, said to his fireman, "It strikes me that the whole train is not there, mate." He shut off steam and had reduced the speed of his train considerably, and was proceeding cautiously, when they saw in the distance a red light waved violently. They pulled up at once, and that easily, when they found the red light belonged to the rearguard of the goods train, and as he held his bull's-eye light full in their face he informed them that a wagon axle belonging to his train had broken and thrown ten trucks across their road. The guard got on to the step of the engine, which was then moved close to the scene, when both driver and fireman saw sufficient to convince them that something else besides driving and firing are required to make good railway men.

Every engine failure is the result of one of two things: it is either a deviation from what the builder intended, or it is a deviation from perfect enginemanship, and we cannot tell what the deviation—the something wrong—is, until we know what the thing deviated from—the prior something right—was.

Things appertaining to the foot plate generally find their place in men's experience and little in books.

I have dwelt on the start (we have been under steam), we have noticed how to treat the engine with the lever; how and when to fire; we noticed that something more than locomotive knowledge is necessary upon a railway—namely, a thorough acquaintance with the signals, with the gradients, and the traffic; we will now briefly review the last part of a trip. From the start the fire should be kept up *well* round the fire box until experience cries—hold! This may happen 60 miles from the terminus, or it may be only 30 miles; all depends upon the weather, the load, and the gradients.

But when the last portion of the trip is entered the small coals should be used. Get in sight of home, so to speak, before the small coal is put on.

It should be put into the two back corners with the shovel, as the vibration of the road will carry it into the center.

Experience teaches a driver how much coal his fire box holds, and say he is 50 miles from the terminus, he looks and sees he has got about 10 cwt., and that is 22 lb. per mile if it took him right home. Locomotive engines, working heavy express trains, do well if they keep time with about 28 lb. per mile of hard coal, and 24 lb. per mile of Welsh coal. We are in this last portion of the trip; there is, say, 10 cwt. of coal in the fire box as the engine moves along on her journey; in time all the smoke has been consumed out of the coals, and nothing but pure carbon remains, and every facility is then given for the fuel uniting chemically with the oxygen of the air, and the result is perfect combustion. But perfect combustion has never gone on before in this trip until now, and the tubes and smoke box are coated with soot or unburnt carbon; and carbonic acid being formed, attacks the unburnt carbon in the tubes, and it peels off the tubes. Hence, when running in with a pure fire, it very often happens that the engine is very free of steam, simply because the soot is a non-conducting substance in the tubes which has been displaced, and the bare skin of the tube is exposed to the heat.

Some fires require more attention than others, and they do not burn down level all round, which is owing to the air spaces between the bars being uneven, or if some tubes are stopped up, the fire underneath them is not forced so strongly as the portion lying directly in the way of the blast drawn through a clean tube.

So if the fire is uneven when finishing, it is well to carefully level it with a fire iron, and at the same time crack the clinker if there is one when the oxygen of the air will destroy it gradually.

After the engine has arrived at the end of its trip, it should be immediately examined all round, because if this performance is left until the engine reaches the shed, which may be an hour or two, what was hot on the shed will be either cold or only warm, thereby very much deceiving a man. The engine should be thoroughly overhauled, and the valves and pistons tested, and the smoke box examined.

From the start to the finish everything demands close attention, and there is not a body of men in England who try to give satisfaction like our brave engine men of the iron horse.

IRON RAILWAY SLEEPERS.

THE Prussian Minister of Trade, Dr. Achenbach, has lately issued a formal notice to the various state railways, enjoining them, in consequence of the favorable results of experiments with iron sleepers—especially those of the Hilf system, to give these a more extended use upon their roads. Already the number of German railways, which to a greater or less extent are laid on iron, is considerable. The Hilf sleeper has been some time in use on the railroads of Nassau and other lines, is being extensively tried by the Belgian Government, and has lately been definitely adopted as the sleeper for the great strategical railway which is being made from Berlin to Coblentz, Trèves, and Thiacville, connecting the German capital with its newly acquired possessions on the frontier of France. Altogether not less than 1,000 miles of track are now laid with this single system. In Belgium, 10,000 Vauthevin iron sleepers were laid down, as long ago as in 1869, on the Grand Central Railway, and although these have been in some measure condemned, yet the use of iron has been continually extended in that country, under the superintendence of its leading engineers. In France several of the great lines, notably the Chemin de fer de l'Est, have experimented on various forms of iron sleepers, and have them still in use with more or less favorable results. We will not dwell on such countries as India and South America, where iron is rapidly supplanting timber in all directions, because it may be agreed that the conditions of climate in those regions make them useless as a guide for English practice. But the case of Germany is especially to be remarked, because the railway timber is there entirely of home growth, being produced by the enormous forests of that country, and forming an important constituent of her internal trade. On the other hand, in England, almost every sleeper is an imported article, brought long distances across the ocean, at a cost which, of course, goes mainly into the pocket of the foreign grower, whilst, as at the present moment, our own iron forges and furnaces may be languishing for lack of employment. Looking at the present disastrous state of things in the iron trade, it can hardly be denied that he would deserve well of his country who should point out how an imported article in timber could be replaced by a home-made one in iron, provided it was at an equal, or even a slightly greater, first cost.

We need not say more to show that the question we ask is not superfluous; and it is scarcely needful to remark that it is far from being unimportant. In this connection we may, perhaps, repeat some rather startling statements for which the journal of the *Verein Deutschen Eisenbahn Verwaltungen* is responsible. Here it is assumed that an iron sleeper weighs 35 kilogrammes, and that 100 sleepers require to be renewed annually for each kilometer of railway. The yearly weight of iron required for each kilometer will thus be 3½ tonnes, and as Europe possesses about 112,800 kilometers of permanent way, it follows that the yearly consumption of iron thus attained would be 401,800 tonnes—or say, in round numbers, 400,000 English tons. We think this estimate considerably too high, but it must be remembered that this applies to the renewals on existing lines only, and allows nothing for new lines, fresh sidings, etc. At the present low rates—say, £6 per ton—the estimate represents an annual money value of about £2,400,000, which is certainly sufficient to give the question of this substitution an undoubted commercial importance.

It is to be noticed that cast iron has found most favor with English engineers, and has been extensively used by them, not indeed in England, but in India, South America, and other countries; while wrought iron has been everywhere preferred on the Continent, and all the developments going on now are in that direction.

Cast Iron Sleepers.—One of the earliest and at the same time one of the most successful forms of cast iron sleeper is the "pot" sleeper of Mr. Greave. The principle of his design is to use the ordinary cast iron chair for the actual support of the rail, and simply to extend the base of this into a large bowl-shaped surface, which is sunk in the ballast and carefully packed in the inside. This sleeper is shown in elevation and plan in Figs. 1 and 2.* It will be seen that the jaws of the chair are strengthened by ribs, and hold the rail with a wooden key in the ordinary manner. The hollow base is provided with openings, A, A, for inserting ballast to pack the interior. The width of gauge and the level of the sleeper are alike maintained by the cross-tie B, which consists of a bar of flat iron set edgeways, run through openings in both the corresponding sleepers, and secured to each by a cotter, C, and pin, D. The Greave sleeper, originally tried in 1847, on the Lancashire and Yorkshire Railway, was selected by Robert Stephenson, as early as 1851, for the railway across the Isthmus of Suez, as being the form best suited to the conditions of climate and to the nature of the ballast, which consisted partly of sand and partly of alluvial soil from the Nile. The wisdom of the choice has been confirmed by the reports of the engineers in 1862 and 1865; but it must be added that complaints from travelers as to the roughness of the road have not been wanting. Greave sleepers were subsequently adopted by the Madras and Calcutta Railways, and on the Mooltan Railway in the Punjaub, where they were reported on as forming an exceptionally good road. They have also been used extensively in Brazil and in the Argentine Republic, where they replaced the Barlow rails originally employed. On the other hand, Mr. Sibley, the engineer of the East Indian Railway, decided against them after considerable expense, and replaced them by a wrought iron system of his own, which we shall describe hereafter. The "pot" or "bowl" sleeper has received modifications and improvements at the hands of several inventors. On these we shall only touch briefly. The chief variation attempted was to make the base of the chair a mere flat plate, strengthened by ribs underneath, thus doing away with all difficulties as to packing the ballast. Of this character were the sleepers of Mr. Samuel, of Mr. Peter Barlow, laid down on the South-Eastern Railway in 1849, and afterwards tried on the Midland and Eastern Counties Railways, and of M. Henry, tried on two of the railways in France. None of these obtained any lasting favor, in consequence, it would appear, of their liability to fracture and their small hold on the ballast. Quite recently the same type has been revived by M. Mounier, of the East India Railway. His sleeper is a broad flat plate turned over at the two ends to grip the ballast, and having across its middle a trough-shaped depression, which is filled with a half round block of hard wood. On this the rail, which is double-headed, rests, and is secured by a cast iron jaw on each side, bolted to the top of the sleeper. A rib runs longitudinally under the sleeper from the middle to each end to stiffen it; or in some cases the sleeper is hollowed into a similar depression along its center, through which the tie, which is a round bar, passes. We are not aware whether this design has been tried in practice. The Griffin sleeper, on the other hand, has been widely used in South America, but is in essentials the same as the Greave. The chief differences are, as shown in Figs. 1A and 2A, that the outline of the bowl is oval, or oblong, instead of round, that it has a flat lip round the edge, and that the surface is cast in corrugations radiating from the major axis, so as to increase the strength. A recess runs along the whole length of the top, having a section much like the jaws of a chair. In this the rail rests, and is secured by a strip of teak, on the outside, and by an iron key on the inner side, or where two rails meet, a single fish plate takes the place of the latter. The tie-bar is of wrought iron, not passing right through the rail, but inserted in a recess in its side, and simply wedged up with a common taper key. But the bowl sleeper has been now brought to what is probably its fullest development in the hands of Mr. James Livesey, of Westminster. In Figs. 3 and 4 are given a plan and elevation of Mr. Livesey's cast iron sleeper for a double-headed rail in its most improved form; in Fig. 5 is a perspective sketch of a similar sleeper arranged for a Vignoles, or flat bottomed rail. It will be seen that the bowl in this sleeper is decidedly shallower than in Greave's, and has a flat lip round the outer edge, which tends to prevent the sleeper from rising. The openings in the bowl for packing are also done away with; these were found to do more harm than good, as the ballast had a tendency to work up through them, under the action of the trains. The comparative shallowness of the bowl makes the task of packing more easy, while it still retains ample holding power in the ground. As a matter of fact no trouble is found with the packing, which is done in one of two ways. In the first the sleeper is laid on its back close to the spot where it is to rest, carefully filled with ballast, and then turned suddenly over into its proper position. In the other a small heap of ballast is first formed at the proper spot, then the sleeper is dropped over the top of this, and finally the packing is completed by ramming it under the edges. The shape of the bowl itself is oval, and the jaws of the chair, instead of being two are three in number, of which two, A A, are close to the ends of the major axis, and one, B, opposite to them in the middle, the rail is laid in place and then fixed against the faces of jaws, A A, by a cast iron wedge-shaped key inserted between the web of the rail and the face of the central jaw. The arrangement of this key is simple and ingenious. Its outer side is formed into a series of shallow parallel corrugations, and a set of precisely similar corrugations is cast on the face of the jaw. The key, C,

FIG. 1

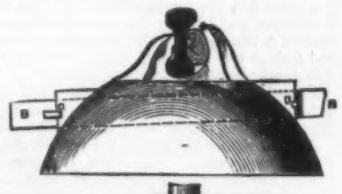
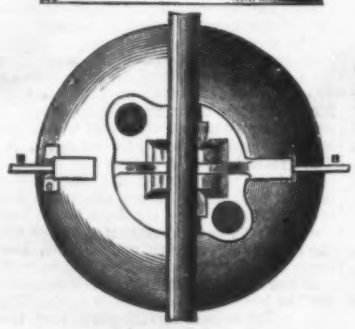


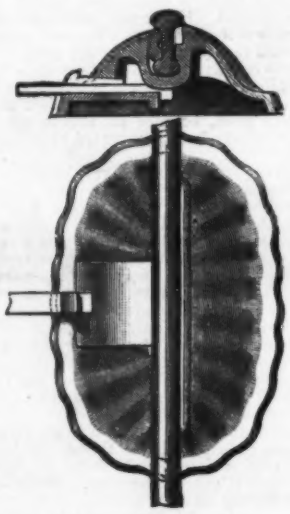
FIG. 2



GREAVE'S POT SLEEPER.

FIG. 1A

FIG. 2A.



GRIFFIN'S SLEEPER.

* Von Waldegg, Atlas to Vol. 1, plate 14, Figs. 1 and 2.

is put in place and then driven home with an ordinary plate-layer's hammer; the rail springs sideways at each stroke, sufficiently to let the corrugations of the key work past those of the jaw, the two falling together with an audible click each time that the ridges of the one come exactly opposite to the furrows of the other. When the wedge has been driven thoroughly home the two corrugations are of course firmly interlocked, and no possible amount of vibration can shift the key either way, while it is at any time readily loosened by a few blows of the hammer on the small end. It will be observed from the elevation that the key bears against both beads of the rail as well as against the web, and that as the jaw, B, overhangs slightly, the rail cannot possibly rise without first moving laterally, which it is prevented from doing by the jaws, A A. So thoroughly is the rail thus secured that in the arrangement for Vignoles rails—as is seen from the perspective view, Fig. 5, the two end jaws have plain vertical faces to resist lateral motion only, all tendency to rise being overcome by the central jaw with its key. This gives a better form for the moulder, and thus cheapens the casting materially. In order to increase the elasticity of the road, and prevent all noise, a square recess is cast at each end of the sleeper, as shown in Fig. 5, and loosely fitted with a block of creosoted hard wood, oak, or elm, on which the rail, whether flat-bottomed or double-headed, takes its actual bearing. The arrangement for tying each pair of sleepers together, and so preserving width and uniformity of road, is simple, and appears sufficient. The tie is a simple bar of flat iron, about 2 inches by ½ inch, having a rectangular hole 1¼ in. by ½ in., punched at about 6 inches from either end. This bar runs through openings, D D, Fig. 3, made for the purpose in the bowl of the sleeper, and in doing so passes across a recess formed in the top of the sleeper, and having a curved bottom as shown in Fig. 5. The tie bar is adjusted so that its hole comes fair with this recess, and it is then secured by a key, consisting simply of a piece of 1¼ in. by ⅝ in. iron, of the right length, just to lie wholly within the recess, and bent hot, to a radius somewhat larger than that of the recess bottom. The effect of driving this key home through the tie bar is therefore to raise the latter a little, and jam it firmly against the top of the sleeper, whilst the rail when laid above forms an effectual lock, preventing the key from shifting in either direction except to a very small extent. In practice all these parts are supplied from the same works, and made with sufficient accuracy to be perfectly interchangeable, and go together without any difficulty whatever. The laying or the repairing of the road thus requires no tools except a hammer, and no skilled labor whatever, it being quite impossible for any of the parts to be mistaken or misplaced.

The Livesey cast iron sleeper, as well as a similar form in wrought iron, of which we shall speak hereafter, has been extensively used in various parts of the world. The Great Southern Railway of Buenos Ayres, a very flourishing line, has had its road laid for several years past with cast iron sleepers and steel rails, and the result is that their charges for repairs are almost nominal. Other lines which have used the system are the Oude and Rohilcund in India, the Cape railways, the railways of Mexico and Jamaica, and the Central Argentine Railway. By the kindness of Mr. Charles Douglas Fox, we are able to lay before our readers a copy of the specification for a supply of Livesey sleepers, tie bars, and keys, lately ordered by him for the last named railway, which is now laid through almost its entire length on this system.

"*A, Sleepers.*—The sleepers are to be of the form and dimensions shown on the accompanying tracing; the sleeper and key is to weigh 95 lb. They are to be clean castings, free from cracks, flaws, and all other defects. The mixture of metals for casting will be left to the manufacturer's judgment, but it must be of such quality that a test bar 3 ft. 6 in. by 2 inches by 1 inch placed edgewise on bearing 3 ft. apart will acquire no permanent set whatever, under a central load of 5 cwt., applied during a space of five minutes, and the same bar on the same bearings must not break under a less central load than 30 cwt., and the deflection before breaking must not be less than $\frac{5}{16}$ in. Test bars are to be run from every melting, and tested in the presence of the inspector. No casting will be accepted which shall have been run from the furnace from which test bars have been cast which fail under either of the above tests. Such of the sleepers as the inspector may daily select are to be tested with a falling weight of 3¾ cwt., in such a manner as may be directed. The candidate must provide apparatus for testing the sleepers, as well as all necessary assistance and labor the engineer or his inspector may require for making the tests above directed.

"*B, Cast Iron Keys.*—The cast iron corrugated keys must be of the form and dimensions shown on the tracing, and the quality of the castings must be in every respect equal to that of the sleepers. Special care must be taken that the touching surfaces are smooth and even and the corrugations regular and corresponding exactly with those in the key-jaw of the sleeper both in curve and pitch, so that they may drop into each other with a click when the key is driven in. When the key is driven home it should be in the center of the key-jaw, and no key will be accepted which varies from that position more than to the extent of the corrugations either way.

"*C, Wrought Iron Tie-Bars and Cotters.*—The wrought iron tie-bars and cotters are to be of the form and dimensions shown; they are to be made from some "best best" description of iron, the brand of which is to be submitted to and approved by the engineer; the said iron must be capable of standing a tensile stress of 20 tons per square inch of section without fracture. The ends of the tie bars must be cut off square, and two slotted holes of the size and in the position shown must be punched at one operation in each of the bars for the reception of the cotters, or if the holes are punched separately, a gauge provided with a nipple placed at the proper distance must be attached to the punching machine, and when the first hole has been punched it must be dropped on to the nipple while the second hole is being punched. The tie bars are to be made to weigh 23¼ lb. each. The cotters must be accurately curved as shown; they must be made just to pass through a gauge provided for the purpose, and no cotter will be accepted which is found either to get too tight or too loose. The cotters are to be made to weigh 1½ lb. per pair. The tie bars and cotters are to be heated to a proper temperature, and dipped while hot into boiling linseed oil, or other preservative compound to be approved by the engineer. Proper gauges must be provided by the contractor for testing the accuracy of form of the sleepers, especially those parts that receive the rail top. Gauges must also be provided for testing the accuracy of form of the tie bars, cotters, and keys. The articles herein specified must not weigh more than the calculated weights given, and any variation above and below them, if more than 1 per cent., will not be allowed, and any excess of weight beyond this limit will not be paid for."

The above specification gives a clear idea of the design and workmanship of the Livesey sleeper, and of the accuracy desirable in its manufacture. With regard to the important question of cost, the sleepers cannot of course be produced at quite the same low rates as ordinary cast iron chairs; but we have reason to believe that for a good order, even with the severe specification just given, there would be no difficulty in obtaining the sleepers complete with keys, tie bars, and cotters all ready for laying at an all round price of about £4 15s. per ton. Now it will be seen that the sleeper and key are specified to weigh together 95 lb.; the tie bar, 23¼ lb.; and the pair of cotters, 1½ lb.; giving a total weight per set of say 215 lb. As the sleepers are laid about 3 ft. 9 in. apart, center to center, this gives a weight per yard forward of 172 lb., and a cost at the above figure of 8s pence. It will, of course, be observed that we have left the rail out of consideration. We have done so because the design of the rail must in great measure be independent of the sleeper that is to carry it; and also because the varieties of design are so numerous, that to introduce them into the question would complicate it beyond all possibility of comparison.* We shall therefore refer the various systems of permanent way we have to consider as far as possible to the weight and cost of material per yard forward exclusive of rails. Any subsidiary advantages as to the use of a cheaper form of rail, facility in laying, etc., we shall not omit to state in each case, but without undertaking to reduce them to a money value. Thus with regard to the Livesey sleeper, when used with Vignoles rails, it may be pointed out that the flange of the rail, bearing as it does on hard wood or iron, need not be so broad as where it rests on the soft fir of an ordinary sleeper; and that the material thus saved may either be dispensed with altogether or transferred with advantage to the head. Again, with a double headed rail resting on hard wood, the under surface will not be bruised so rapidly as when placed in an ordinary chair; and a reversible rail may therefore be employed with more advantage.

The Livesey sleeper may probably be considered to represent the furthest development to which the use of cast iron can be extended as a material for permanent way. Before leaving, however, this part of the subject it will be well to give briefly the opinions of various engineers as to cast iron sleepers in general, especially as these form a class by themselves, differing alike from timber and wrought iron sleepers in their mode of application.

M. Kirsch, engineer of the Grand Central Railway of Belgium, has published two important articles on iron sleepers in the *Revue Universelle des Mines* for 1875 and 1877. In the first of these he briefly discusses cast iron, especially as exemplified in the sleepers of Greave and Griffin, and brings against them the following objections: 1. They require a very fine and dry ballast such as sand; for if the ballast be large it is very difficult to pack it properly into the hollow of the sleeper, and if it be at all moist and clayey it quickly forms in combination with the rain water and rust which collects within the sleeper a hard, stony cake, which destroys all elasticity in the road. But dry sand ballast is, of course, of unfrequent occurrence, and where found it is very liable to be washed away and disturbed during heavy storms. 2. The bowls of the sleepers being thin, and buried only to a small depth, the ballast inside is very soon frozen during winter. 3. The bowls are very apt to be broken during the process of packing. 4. In wet weather or under heavy traffic, the two opposite sleepers are apt to sink unequally, thus bringing the road out of level in a way very difficult to correct. 5. From their comparative lightness and inefficient hold on the ballast they are not strong enough against lateral displacement of the rails, and generally render the road unstable. The conclusion is thence drawn that cast iron sleepers are only fitted for dry tropical climates where sand is the usual ballast, and where, moreover, timber of any kind is subject to rapid decay.—*The Engineer.*

Fig. 3.

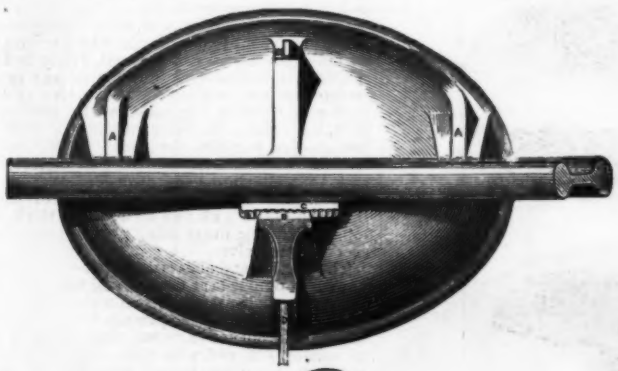


Fig. 4.

Fig. 5.

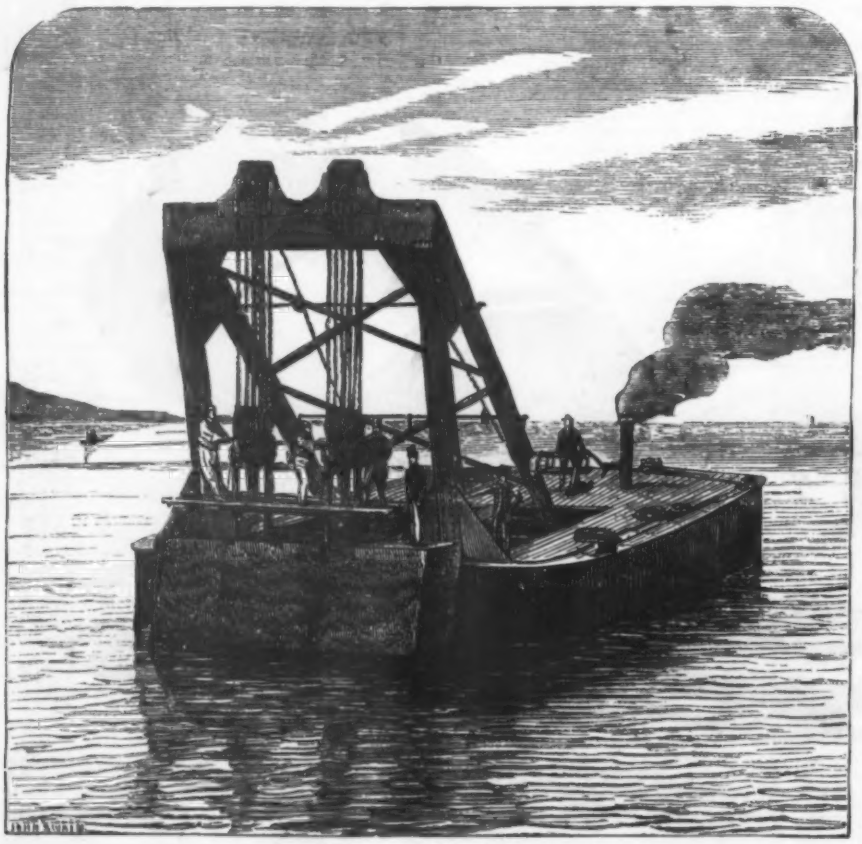
LIVESEY'S PERMANENT WAY.

THE STATHMOGRAPH, AN INDICATOR OF SPEED ON LOCOMOTIVES.—The apparatus devised by railroad inspector Dato, of Cassel, for indicating the speed of a locomotive, at any instant, to the engineer, accurately upon a figured scale, has been found to answer perfectly, after trial for a year, on a locomotive on the Hanoverian railroads. It furnishes besides an accurate record of the run on a strip of paper. On account of the great value of such an apparatus in increasing the security of railroad trains the Prussian railroad administration has determined to introduce it for the present, for further trial of its practical operation, upon several roads, and its trial has been recommended by the imperial government on all German railroads.

* In the "Roorkee Treatise on Civil Engineering," vol. ii. p. 328, it is stated that in India the cost of Greave's sleepers was found to average £1,500 per mile, as against £1,307 for English creosoted fir, or £1,101 for Indian wood. No details are given, but it may be presumed this represents the cost of the sleepers, chairs, etc., exclusive both of rails and ballasting; in which case a road of Livesey sleepers at present prices of iron would probably not exceed in cost one of European, if not of Indian timber.

LARGE FLOATING SHEERS.

A DEEP-WATER quay, 600 ft. in length and 40 ft. in width, is now in course of construction at Queenstown Harbor. It is estimated to cost £30,000, for nearly half of which the Great Southern and Western Railway Company is responsible. This will place the quay very much in the hands of the railway company, who will thus have considerable control over the direction to be taken by goods landed close to their own trucks from the American steamers. Possessing similar accommodation at Northwall, Dublin, the time of the journey from Queenstown to England may be considerably shortened, and the Great Southern and Western Railway will secure the greater portion of the work. At the lowest state of the tide there will be 27 ft. of water off the new quay at Queenstown, and this will enable Transatlantic steamers to come alongside at any state of the tide and discharge into the wagons of the railway company, thus getting rid of the great obstacle which always prevented Transatlantic steamer companies from loading and discharging at Queenstown. On the 4th of September the first stone, or block of concrete, in the formation of this wall was successfully laid with much ceremony. These blocks are about 20 ft. in depth, 8 ft. in thickness, 12 ft. wide at the sea face, and weigh nearly 120 tons. For laying these large blocks in their places the powerful floating sheers which we now illustrate were made by Messrs. Chas. Powis & Company, of Millwall Pier, for Mr. J. Delany, of Queenstown, the contractor for the quay work. The hull is 90 ft. in length, 32 ft. wide, and 9 ft. 10 in. deep fore, and 13 ft. 10 in. aft. The sheer legs are fixed on the fore end, together with a pair of powerful pulley blocks and chains for raising and lowering the massive blocks of concrete, about 140 of which altogether will be required. At the after end of the hull are constructed six water tanks, capable of holding 150 tons of water, to act as a counterbalance to the block. To these tanks a centrifugal pump is connected, so that they can be



ONE HUNDRED AND TWENTY TON FLOATING SHEERS.

filled when raising the block, and emptied when lowering it, and by this means the hull can at all times be kept on an even keel. The machinery consists of a locomotive boiler, and a pair of 8-horse power horizontal engines, connected by gearing to two drums, each 7 ft. in length by 4 ft. in diameter, and strong chains pass over two powerful pulley blocks, which are attached to the upper part of the sheers' legs, the lower pulley block being fitted to massive forged beams, the ends of which are slotted out to receive the lifting bars, and by this means the huge block is suspended from four points and kept perfectly level. The engines drive a pair of screw propellers, which considerably assist in working the sheers into position. In the bottom of the concrete blocks cast iron plates are cast with rectangular holes to receive the T heads of the lifting bars which are inserted through a hole left in the concrete. The bolts are dropped through with the head in the direction of the length of the hole in the plate. They are then turned, and the T catches against the sides of the hole, and the blocks are lifted. Our drawings give a good idea of the strong proportions of the sheer legs and cross beam, and also of the general arrangement, which seems to be excellently well adapted to the requirements. The principal dimensions of the superstructure and the plates used are given on the drawings, and the principal plates in the hull are as follows: Keel plate, $\frac{3}{4}$ in.; bilge strake, $\frac{3}{4}$ in.; sheer strake, $\frac{7}{16}$ in., doubled for half length amidships; other parts, $\frac{7}{16}$ in. and $\frac{1}{4}$ in.; floor plates, 12 in. by $\frac{1}{4}$ in.; deck stringer, $\frac{1}{4}$ in. for three-fifths vessel's length, $\frac{7}{16}$ in. at ends; frames, 3 in. by 3 in. by $\frac{3}{8}$ in.; reverse frames, 3 in. by 3$\frac{1}{4}$ in. by $\frac{7}{16}$ in. The total cost of this piece of modern contractor's plant was about £5,000, and Mr. Delany has no doubt shown good judgment in thus expending one-sixth of the whole value of the contract for a good tool to carry it out. In adopting the large sizes for his concrete blocks, Mr. P. Barry, the engineer for the work, has followed the example set by Mr. B. B. Stoney and others, and in doing so has probably decided upon what is ultimately the most economical mode of construction.—*The Engineer.*

SAW ACCIDENTS.

THE most prolific cause of accidents in saw and planing mills is the buzz saw; by it from 5,000 to 6,000 persons are maimed yearly. Such a record, says the *Northwest Lumberman*, ought to be an incentive to inventive genius, but until recently it seems that it has worked in the wrong direction. An old mill man of unusual intelligence said that for years he expended his ingenuity upon devices for the prevention of these accidents, but finally gave it up in despair. But despair has no business to show itself in such a place; whatever is necessary to be done will be done sooner or later. Human ingenuity may be weak in one generation, but it grows to be a giant in the next.

J. B. Lukeman, Her Majesty's Inspector of Factories, has invented a device which is in no way protected by patent right, which is cheap, simple and said to be effectual. We copy the mode of construction from an English paper:

The guard consists of three pieces, namely: the mortise-plate, secured by three bolts to the fence; a radial arm, which is secured and adjusted vertically into the mortise plate by means of nut and collar; and the covering plate, which is secured and adjusted laterally into the radial arm, in conformity with the adjustment of the saw fence, by means of the thumb screw. Where several saws of various diameters are used in the same bench, it is advisable to have two, or perhaps three, covering plates, graduating in size to cover the whole series of saws.

As deals are principally sawed in England, of course this contrivance was not intended to cover the class of saws which are used here for converting logs into lumber, but upon the innumerable saws in use in planing mills it would by applicable, and perhaps upon the larger kind it would be found to answer the purpose. The experiment should at least be made. We do not know a mill owner whom we do not think would sooner defray the light expense of applying it than to see one of his men carried out with a severed hand.

Accidents arising from the entanglement of some portion of an operator's garments in a swiftly revolving shaft are of frequent occurrence and often of a fatal character. In Minnesota to run a thrashing machine without having the tumbling rod boxed is a violation of the law, and there ought to be a law in every State that shafts, so far as practicable, should be so protected as to insure the operators against accidents.

A simple way of rendering these casualties impossible is to cover the shaft with a loose sleeve, which may be of sheet iron or zinc. It should be covered within and at the ends with leather to prevent noise. Arranged in this manner the friction between it and the revolving shaft would be sufficient to cause the sleeve to rotate with the latter, but in the event of any decided resistance the sleeve would at once be brought to a rest. The same idea of loose covers may be applied to cog wheels or pulleys, and prove an invaluable protection against loss of life or injury to persons.

Accidents to operators running parallel edgers are numerous. For a while they were looked upon as necessary. If a board flew back and impaled a poor fellow, it was simply considered as a streak of ill luck, but no efforts were made to construct the machine on less demonstrative principles. There is now an edger made by the Union Iron Works, of Clinton, Ia., which for safety of operation is said to be the best in use. If the claims made by the manufacturers of the machine can be substantiated, the mill owner who does not adopt it can be charged with culpability in almost the widest meaning of the word. If accidents from these three sources were properly guarded against, they would materially decrease in number.

In these days when machinery seems almost imbued with instinct, skilled hands do not play the part they once did, but skilled hands are a necessary adjunct of skilled machinery, and no mill owner can afford to peril the limb or life of a competent man, for the best men, like the best of everything, are not generally lying idle, and their places are usually hard to fill. Moreover, a broken rib or leg, an ugly gash by a buzz saw, not only means the pain incident to such a happening, but often want to the family that depends for support on the earnings of the injured.

NEW WATER WORKS, LEAMINGTON, ENG.

THE work of making the new wells and bore holes was first let by contract in November, 1876, but apparently operations proceeded slowly, and the borough engineer took the work up in 1878, and completed it in March last, 1879.

The well is situated on the northeast side of the town, at the foot of the Newbold Hills, about 214 ft. above the level of the sea. There are two wells, as shown in the section given on page 3278, one 7 ft. 6 in. inside diameter for a depth of 108 ft., lined to a depth of 90 ft. 6 in. with 14 in. brickwork, the remainder being lined with cast iron cylinders, formerly resting on a cast iron plate at the bottom. At the bottom is a bore hole 20 in. in diameter to a depth of 100 ft., and 12 in. in diameter for a further depth of 34 ft., making a total depth of 242 ft. 6 in. from the surface of the ground.

The other, or main well, is 20 ft. diameter, and 112 ft. 6 in. in depth, lined with brickwork to a depth of 97 ft. 6 in., the remainder of the well being in rock. At the bottom is a bore hole 20 in. in diameter to a depth of 100 ft., making a total depth from the surface of 212 ft. 6 in. The two wells are connected by an adit 50 ft. in length, 6 ft. in height, and 4 ft. wide, the mouth in the small well being protected by a sluice which can be opened or shut from the top. The back of the brickwork of both wells is puddled, 2 ft. in thickness, to a depth of 40 ft., to keep out surface water. The permanent pumps are fixed in the large well. These consist of two pairs of 18 in. bucket and plunger pumps. The suction pipes, which rest on stones at the bottom of the well, are made of copper, and at the bottom of each is fixed a grating to prevent any *débris* from choking the pumps. These are 14 ft. 6 in. in length, and are bolted to the permanent pump barrels, which rest on cast iron girders built into the sides of the well, firmly bedded on stone, and filled in behind with Portland cement concrete. These girders are also supported by massive cast iron columns, resting on concrete foundation at the bottom of the well; 23 ft. 9 in. above the lower girders are built in other cast iron girders, to which the pump barrels are bolted. The two which support the air vessel, sluice valves, relief valves, and rising main are made stronger to carry the increased weight. The pump barrels are made of cast iron 1$\frac{5}{16}$ in. thick, and lined with gun metal $\frac{5}{8}$ in. thick, tapering at the top and bottom; doors being provided so as to afford ready access to the valves.

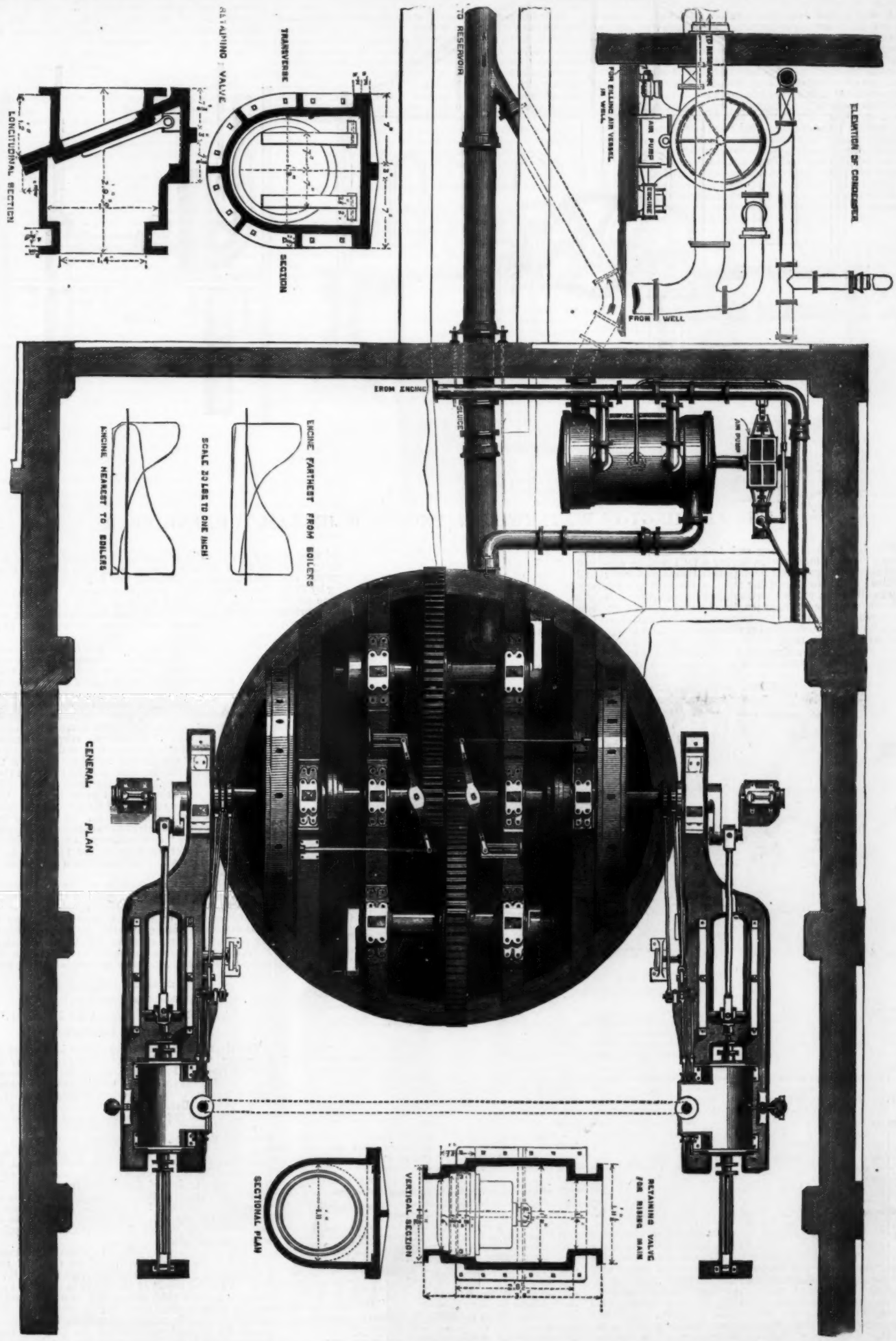
The suction and delivery valves are of the kind commonly known as double-beat Cornish; all the parts exposed to wear, the springs being made of gun metal. See illustration, next page. The stroke of the pump is 5 ft. The connecting rods between the bucket valve and plunger are of wrought iron, 4 in. square, stiffened with pitch pine. The plungers are of cast iron, 1 ft. diameter and turned, 8 ft. in length. The pump barrels are extended upward from the working barrel 18 ft., on the top of which are placed the stuffing glands, lined with gun metal. To the plunger are fixed the pump rods. The pumps are connected with the air vessel and rising main by cast iron pipes, 13 in. inside diameter, having each a relief valve, properly weighted, and a sluice valve to open and shut from the top, double faced with two gun metal faces and gun metal spindle and nuts. Owing to the difficulty of fitting these four pipes to the air vessel, it was necessary to provide special pipes, made similar to those used for expansion joints in steam pipes.

The air vessel is of cast iron, of a capacity of 30 cubic feet, strongly fixed on to a sole plate, resting on the cast iron girders before mentioned. It is fitted with gauge and pipe from the air pump at top. The rising main in the well is 16 in. diameter inside, made of cast iron flanged pipes 1$\frac{1}{16}$ in. thick. At the bottom of the rising main is placed one of Thomas and Porter's patent retaining valves. The water is conveyed from the top of the well by means of cast iron pipes through a valve chamber where sluices and branch pipes are placed, so that the water may be turned either into the reservoirs, or on to the town direct, or down the sewers, care being taken to prevent any direct communication between the water mains and the sewer by means of a brick trap, the sewer being ventilated direct into the chimney shaft. Thence the water is conveyed across the fields to the reservoir by a cast iron pipe, 16 in. in diameter, 1 in. thick for a length of 900 ft., and $\frac{7}{8}$ in. thick for the remainder of the 1,700 ft., the distance to the reservoir from the pumping station. In the well are seven stages, made of elm plank, the approach to which is by means of wrought iron ladders 2 ft. wide, with galvanized rope for hand rail. On the top stage is placed the gearing for moving the sluices to control the water from the pumps. Galvanized iron air pipes are also carried up from the pump barrels to the top stage, with suitable cocks.

The pumps are arranged in pairs, and worked by wrought iron crank shafts across the top of the well. The pump rods are of 4 in. diameter, rolled by the new cold finishing machinery of the Kirkstall Forge Company, passing through guide rollers on cast iron girders, so made that the rods may be easily removed. The connecting rods are of wrought iron, rectangular in section, bushed with gun metal at their lower ends to receive crosshead pins, and fitted with gun metal bearings and straps, gibs, and cotters at the crank ends. Each pump crank shaft has keyed on to it a cast iron spur wheel of eighty-one teeth, 4$\frac{1}{2}$ in. pitch, 12 in. wide on face. Between the pump crank shaft is placed the pinion shaft, on which are mounted two cast iron pinions adapted to slide on feathers, so as to be readily put into or out of gear with the spur wheels on the pump crank shafts. The pinion shaft is fitted with face plate couplings at each end which correspond to similar couplings on the outer ends of the engine shafts. By these arrangements either engine may be coupled to the pinion shaft, and made to drive either or both pairs of pumps, or, if required, both engines may be coupled to the pinion shaft, and made to drive either or both pairs of pumps.

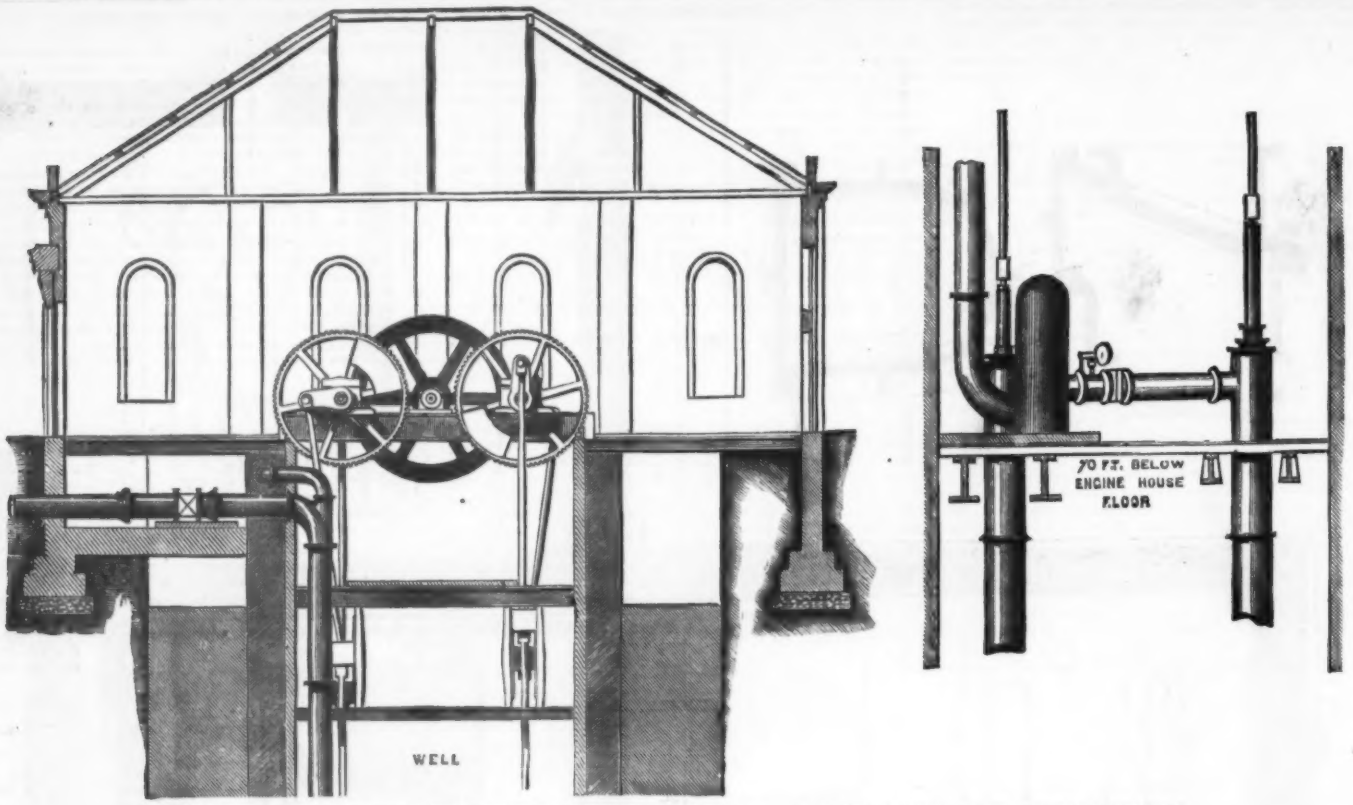
The wheels and pinions shown in the illustration opposite, being in the ratio of four to one, the engines make forty revolutions per minute when the pumps are working at their normal speed. The engines are two in number, arranged one on each side of the engine house, the well and gearing being between them, as will be clearly gathered from the plan on next page. They are of the horizontal type, each having a single cylinder 21 in. diameter, 3 ft. 6 in. stroke. The valve gear consists of a through ported main slide, with an expansion valve working on the back, the cut-off being adjusted by a variable link, the range of the cut-

LEAMINGTON WATERWORKS.—ENGINES AND PUMP GEARING.



off being from about one-fifth to the six-tenths of the stroke. The fly-wheels are 12 ft. in diameter, and weigh each about eight tons. The steam for the engines is produced in two Lancashire boilers, each 30 ft. long by 7 feet diameter, the flues of which are 2 ft. 8 in. diameter, and are fitted with Galloway tubes. The boilers are fitted with dead weight and Hopkinson's safety valves, and the usual mountings. They are intended to work at 60 lb. pressure. They are covered with cement composition by Mr. G. Lester, of Birmingham.

With three pumps working at nine strokes per minute, drawing and lifting 174 ft., the two engines indicate about 150 horse power, and the quantity of water raised is over 90,000 gallons per hour. It is only necessary to work the engine and one pair of pumps for a space of about seven hours daily, to supply the daily consumption; the total quantity capable of being pumped to the reservoirs in twenty-four hours is 1¼ million gallons. The total head on the pumps to the reservoir is 187 ft. The water is of considerable quantity, but it descends as pumping goes on, and rises to about the original height by the time pumping is required to be recommenced. The engines are fitted with a large surface condenser, placed in a chamber under the level of the engine house floor, at the northeast corner of the engine house.

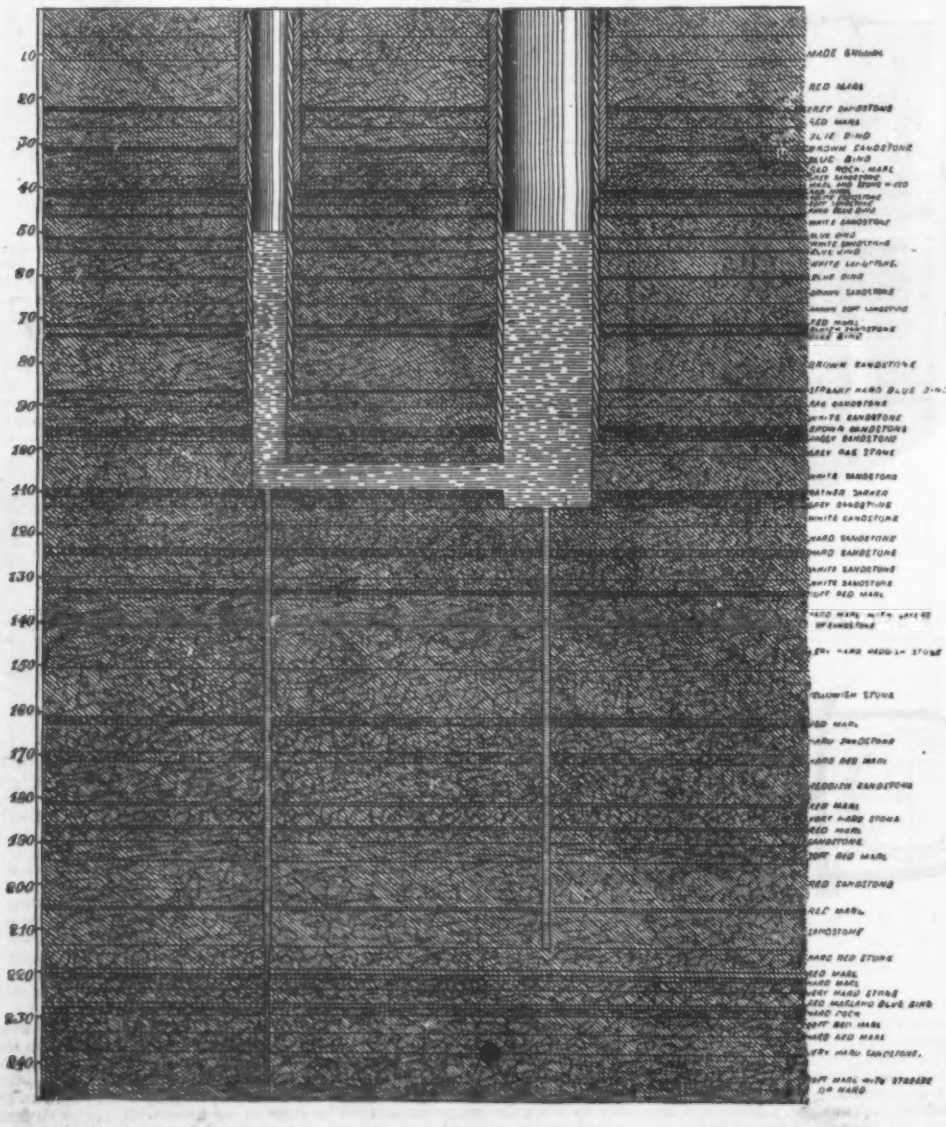


THE LEAMINGTON WATERWORKS, ENG.—G. B. JERRAM, C. E., ENGINEER.

The cylinder is 6 ft. 9 in. long and 4 ft. diameter, having 460 brass tubes, $\frac{5}{8}$ in. diameter, having a total cooling surface of about 460 square feet. The circulation of cold water is obtained direct from the rising main in the well by a by-pass 9 in. diameter, provided with sluices so as to either use condenser or not, and to regulate the circulation. The exhaust steam is carried from the engines by 7 in. cast iron pipes, with three double seated equilibrium valves and stop valves, so as to work from either engine. The condensed water is pumped by the air pump into pipes leading to the cistern in the boiler house. A tell-tale is provided to indicate the depth of water in the well, and pressure and vacuum gauges to show the pressure of water on the rising main and the vacuum in the condenser. Over the large well and engines the engine house is erected, 53 ft. long by 37 ft. wide, and lighted on three sides. There is a stone plinth round outside, the remainder of the building being in brick. The floor is flagged, except that portion over the condenser, which is of cast iron checkered plates. Adjoining the engine house on the west side is the boiler house, 47 ft. 3 in. long by 19 ft. broad, with open roof, in which are a skylight and open louvers for the purpose of ventilation. The chimney shaft, which is square, and situated at the northwest corner of the boiler house, is 75 ft. in height. Outside the engine house on the north side is a subway, in which the rising main is laid, leading into a valve chamber, 12 ft. 6 in. by 12 ft. 6 in., and 5 feet deep, built of brickwork in cement, covered over with cast iron girders and checkered plates. The small well is also covered over in a similar manner.

Near the engine house on the south side is the cottage for engine driver. The whole is surrounded by a substantial wall, and the grounds are to be laid with grass and shrubs. At the reservoirs there has been built a valve well 12 ft. in diameter, with stone bottom, into which the rising main empties. Pipes are laid into each reservoir, with sluices for turning the water into either reservoir. There is also a waste weir, to prevent the water overflowing, and an iron drain pipe therefrom. An electric telegraph indicator has been erected between the reservoir and the engine house, registering every variation of a foot rise or fall in the reservoir on a dial. This has been worked out from the suggestion of the engineer, and constructed by the Silvertown India-rubber and Telegraph Company, London. The water is received into one or either of the covered reservoirs, each capable of holding 500,000 gallons. In order to lessen the inconvenience which might be caused by any temporary disarrangement of the machinery, duplicate bucket and plunger valves for each pump are provided, as well as pipes for rising main, piston and piston rod, tubes for condenser, etc.

The sinking and construction of the wells were carried out by Messrs. King & Co., under the direction of the late Mr. Dale, of Hull. The general arrangement of the machinery was made by Messrs. C. Powis & Co., and has been erected and the work completed, with many additions, by the present borough engineer, Mr. G. B. Jerram, Assoc. M.I.C.E., with Messrs. Young & Co., of Eccleston Foundry, as contractors, and Mr. Davis as clerk of the works.—*The Engineer.*



SECTION OF WELLS, LEAMINGTON WATERWORKS.

[Continued from SUPPLEMENT, No. 205.]

AMERICAN ENGINEERING.*

VII.—RIVERS AND HARBORS.

THE river and harbor improvements in the United States have been, with very few exceptions, executed by the General Government. Previous to the late civil war quite a number of small works were undertaken, and also some of considerable importance. Among the more extensive earlier works was the Delaware Breakwater, a structure of considerable size and importance, as forming a harbor of refuge immediately north of Cape Henlopen, at the entrance to Delaware Bay. Another important improvement early discussed was the removal of the rocks at Hell Gate, in the easterly entrance to the New York harbor, which has been so successfully carried out within the past few years. Since the civil war the field of government improvements has been greatly enlarged, and there is scarcely a navigable stream in the country upon which some work has not been done in improving the channel. Almost every harbor on the coast has also been the subject of small annual appropriations to improve its entrance.

A very complete description of the Government works will be found in the Annual Reports of the Chief of Engineers United States Army, for the years from 1866 to 1876, inclusive. A general report of the works in progress up to that time was made in 1866, since which time the annual reports describe what has been done during each year. There are also many valuable reports relating to rivers and harbors among the professional papers of the Corps of Engineers. Among them is the Report upon the Physics and Hydraulics of the Mississippi River, by Generals Humphreys and Abbot.

Among the more important works now in progress are the New York Harbor Improvements, which embrace the removal of the remaining obstructions at Hell Gate, in the

* American Engineering as illustrated by the American Society of Civil Engineers at the Paris Exhibition of 1878. Compiled by George S. Morrison, Edward P. North, and John Bogart, Committee, Transactions of the Amer. Soc. of Civil Engineering.

East river, by the United States; the construction of a permanent masonry wall, with projecting piers, around the city, the improvement of the channel of the Hudson river, and connecting the Hudson and the lower Harlem river by a ship canal across Manhattan Island, thus opening navigation between the Hudson and the East river or entrance to Long Island Sound.

The most noted work now going on is, perhaps, the construction of the jetties at the mouth of the South Pass of the Mississippi river. This work has been vigorously pushed by its originator. The jetties have been constructed of mattresses of fascines loaded with stone and extended to the length originally proposed. By the aid of dredging between the jetties in places, in connection with the scouring effect secured by the jetties, a channel has been obtained more than 22 feet in depth.

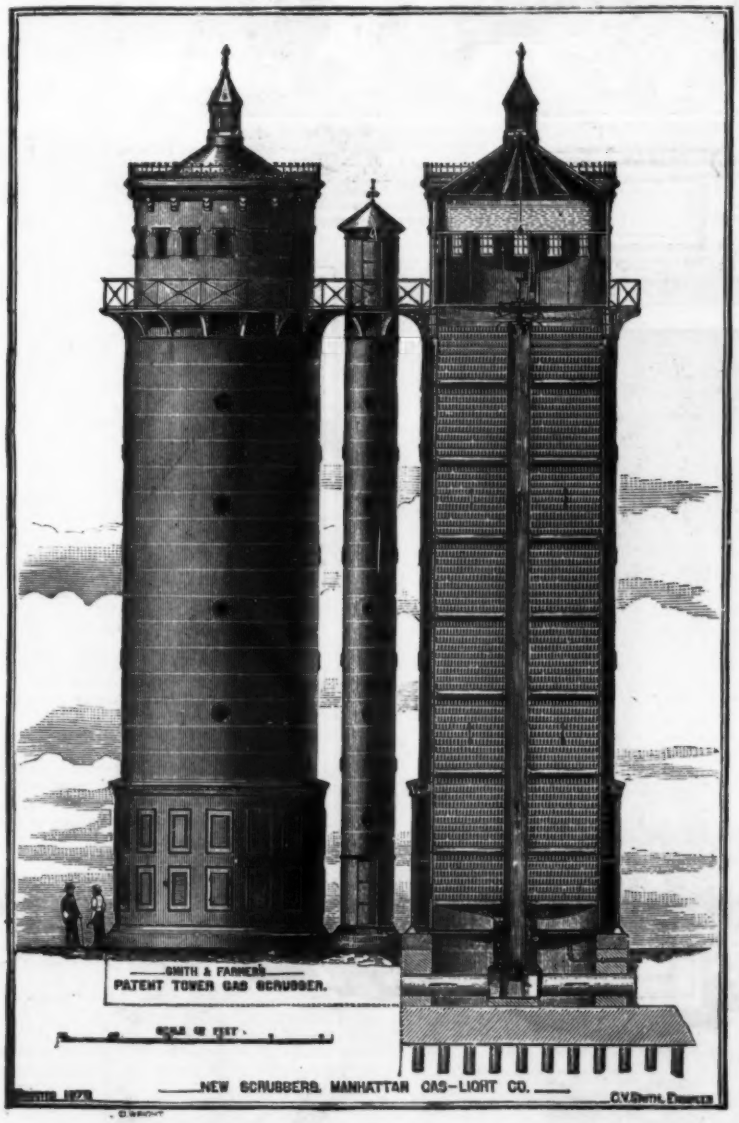
The very important question of embanking the Mississippi to protect and reclaim the great alluvial tracts upon each side, as a Government measure, is now being agitated. Thus far the levee system has been carried on by State Governments and private enterprise, and has been but imperfectly done.

Another great scheme of improvement along the Atlantic seaboard, which was proposed some forty years ago, is now likely to be carried out. This is an internal water communication from New York to Florida. There is a chain of salt water sounds just back of the outer coast, extending through North and South Carolina and Georgia, that can be made available for a continuous water communication, and there is already a communication for small craft from New York to New Berne, North Carolina. A canal is now projected between the Neuse and Cape Fear rivers in North Carolina, as part of the general scheme.

The National Government is at present conducting two important surveys relating to navigation. One, the coast survey embracing the entire seaboard, and the other the survey of the Great Lakes, both of which are being executed with great accuracy. The coast survey is under the immediate control of the Treasury Department, and is chiefly conducted by civilians, while the lake survey is under the immediate control of the War Department, and is conducted by the United States Engineer Corps.

VIII.—GAS ENGINEERING.

To represent gas engineering, the society was able to exhibit drawings and photographs of works and apparatus as employed in this country, which in some respects are novelties. The progress made in this branch of engineering is perhaps more marked than that of any other department. In fact, the beginning of the century knew no such business; fifty years ago New York city had no gas, and forty years since, all the gas supplied to the people of Boston was made in one iron retort.



The amount of capital now invested in this business in New York city and Brooklyn is represented by about thirty millions of dollars, and the number of works, great and small, throughout the country is about one thousand. The principal progress that has been made since the earlier days of gas lighting consists in the various scientific and mechanical means introduced for the proper treatment of the products derived from the destructive distillation of coal, so that while those portions that constitute the light-giving power of the gases evolved are carefully separated in a state of "purity" or freedom from the more deleterious elements, the other portions are still preserved, and handled in such a way as to be no longer "waste products," but sources of revenue in the production of articles of great value and usefulness in the arts. And while this country cannot claim so great a degree of perfection in this latter respect, viz., in the handling of residual products, as has been attained abroad, the reason for this is to be found in the fact that the newness and fertility of our country does not afford the same market demand for these products.

The exhibits under this head consist of—

A detailed drawing of a multitubular condenser.

Photographs of a modification of the Livesey scrubber, with an automatic water distributing apparatus.

A complete drawing of the works of the New York Gas Light Company.

Photographs of the Nassau Works of Brooklyn, etc.,etc., etc.

The multitubular condenser is an apparatus for condensing the tar from the gas. It consists of a cast iron box, or series of boxes with two horizontal diaphragms or partitions —one near the top, the other near the bottom; the upper and lower spaces thus formed are connected by cast iron pipes, usually about four inches in diameter, placed as closely together as possible. The middle space of the box is filled with water, which consequently surrounds the pipes above mentioned.

A series of boxes thus arranged are placed side by side, the gas is admitted into the lower space and passes up through the pipes to the upper space, from there it goes to the top space of the next box, down the pipes to the bottom space, thence into the next box, up the pipes, and so on, thus traveling up one set and down the other until the temperature of the gas is reduced sufficiently low by the water surrounding the pipes to cause the tar, etc., to be deposited in the lower space, from which the tar is run off into cisterns constructed for the purpose. The water surrounding the pipes is admitted from the end of the series of boxes opposite to that at which the gas enters, so that the water surrounding the pipes through which the gas first passes is the warmest (the heat having been acquired by the flow of gas), and that at the end where the gas leaves the condenser is the coolest. In this way the cooling of the gas goes on gradually, and is not too sudden in its change of temperature at any point, and the rapidity of cooling is easily controlled by regulating the amount of fresh water admitted to the condenser.

This form of condenser is largely used in this country, but is almost unknown in Europe, where, as a general thing, the temperature of the air is relied upon to cool the gas, which is passed through pipes out of doors for the purpose. The great advantage of the multitubular method is the almost perfect control that it gives the manager over the rate of cooling. In submitting the drawings of this apparatus, the society was enabled to present a novelty to the gas engineers of Europe.

Of the scrubbers, of which photographs were submitted, and of which a drawing is shown, the principal novelty consisted in the method of distributing the water. The object of the scrubber being to remove the ammonia from the gas by the use of water, by means of the distributer on the top the same water that is used to wash the gas is made to distribute itself by passing from a tank overhead, to which it had been previously pumped, over an overshot water wheel, which, by suitable gearing, turns two arms within the top of the scrubber, into which the water is conducted by a pipe leading from a trough under the water wheel. These arms are in the form of troughs, with notches cut in the edges, so that as the arms revolve horizontally the water drops on to the wooden slats with which the scrubber is filled. These slats being put in edgewise, and kept a small distance apart, a very large area of wetted surface is presented to the gas as it passes through. The ammonia is taken up by the water, which passes off from the bottom as "ammoniacal liquor," and is collected in cisterns built for the purpose. The gas enters the scrubber at the bottom, and passing up to the top, is taken out by a central outlet pipe, which extends to the top. The gas on entering comes first in contact with the strongest liquor, and leaves through a spray of clean water. The strength of the liquor obtained from these scrubbers is from 16 to 20 ounces Twaddle. The quantity of water used is about one gallon to 1,000 feet of gas.

LUBRICANT FOR WOODEN AND IRON COGS.—A lubricant for iron and wooden cogs, recommended by Bauer as having proved excellent in practice, may be prepared by collecting the oil drippings from the machinery and pouring into it melted waste tallow until it forms a smeary mass, and then mixing with it fine, sifted glass powder. The cogs are rendered hard as well as smooth by the glass pressed into the pores.

UTILIZATION OF SOLAR HEAT FOR DRIVING MACHINERY.—According to a communication of Muchot, a solar steam-generator, previously described, erected at Tours, raised more than 5¼ gallons of water from 77° to 250° in 40 minutes, with a pressure of two atmospheres, which subsequently reached five atmospheres, and has proved itself capable of utilizing from 17 to 22 thermal units. In any event it could only be of practical value in warm climates.

COLUMBUS' LOST ANCHOR RECOVERED.

A CURIOUS relic of one of the expeditions which sailed to the West Indies under the command of Columbus has, it is stated by a Martinique journal, been recently discovered. On the 4th of August, 1498, a small squadron of three vessels, under the orders of Christopher Columbus, was anchored off the southwestern extremity of the Island of Trinidad. Late at night Columbus, it is related by Washington Irving, suddenly saw a wall of water approaching toward the fleet from the south. His own vessel was lifted up so high by the incoming wave that he feared it would be either submerged or dashed on shore, while the cable of one of the other ships parted under the strain to which it was subjected. The crews of the vessels gave themselves up for lost, but after a time the wave, which it is surmised must have been caused by an exceptionally large body of water coming suddenly down one of the rivers flowing into the Gulf of Paria, ebbed back again. The sudden rise of the waters of the Gulf is mentioned by Columbus' son, Ferdinand, who adds that the fleet suffered no damage save the loss of one anchor. It is this anchor which has now been found, and, strangely enough, it was dug up from a depth of six feet below the surface of the ground, at a spot 873 feet from the nearest point of the coast line. The land, it is well known, is gaining upon the sea along the shores of Venezuela, so that where once ships rode at anchor gardens are now planted. The anchor itself is of simple form and comparatively rude manufacture, the stock being eight feet long and round, with a ring at one end one foot in diameter to which to make fast the cable, and with flukes five feet long, the whole weighing 1,100 pounds.

DURABLE COATING FOR PRESERVING ZINC ROOFS.

ACCORDING to a German journal, experience is favorable to the introduction of a considerable amount of copper into oily or resinous coatings for zinc roofs, by dissolving some suitable copper compounds in the oils or varnishes employed. It is said that they then unite more intimately with the zinc surface and resist the greatest variations of temperature without scaling off. In their preparation a copper soap, formed by the precipitation of a solution of a copper salt with a solution of soap, may be dissolved in the varnish by boiling, or the solution of a copper salt may be stirred into the Russian emulsion-like train oil pigment, prepared by mixing train oil with a solution of soda or potash, with suitable earth colors, so as to form a thin, liquid water color. A durable black coating for zinc roofs was also published by Puscher, consisting of a solution of equal parts of chlorate of potash and sulphate of copper in 36 parts of warm water. The black coating formed on the zinc by its use must be washed and then polished or varnished.

DEADENING OF WALLS TO SOUND.

THE report of a committee of a Würtemberg association of architects upon the deadening of ceilings, walls, etc., to sound, gave rise to considerable debate, after which the following conclusions were reached. The propagation of sound through the ceiling may be most effectually prevented by insulating the floor from the beams by means of some porous light substance, as a layer of felt, a filling of sand, or of stone coal dust, the latter being particularly effective. It is difficult to prevent the propagation of sound through thin partitions, but double unconnected walls filled in with some porous material have been found to answer the purpose best. Covering the walls and doors with hangings, as of jute, is also quite serviceable.

AN OBJECTIONABLE PROPERTY OF SO-CALLED MINERAL COTTON.—Wolpert cautions against the use of mineral (slag) cotton for filling between floors, on account of the sulphureted hydrogen developed by the action of moisture upon the calcium sulphide, which it generally contains. Any paint in the room containing white lead is thus liable to become discolored, and even the health of the occupants may be affected. It is well, therefore, to test mineral cotton before use in buildings, for calcium sulphide.

TIGHTENING OLD WINDOWS.—Old windows that do not close tightly may be remedied by smearing the edge on which they close with putty, and that of the sash with chalk, and then closing them as firmly as possible. The putty will fill up the crevices, and the excess pressed out at the sides may be removed with a knife, whilst the chalk prevents adhesion to the sash.

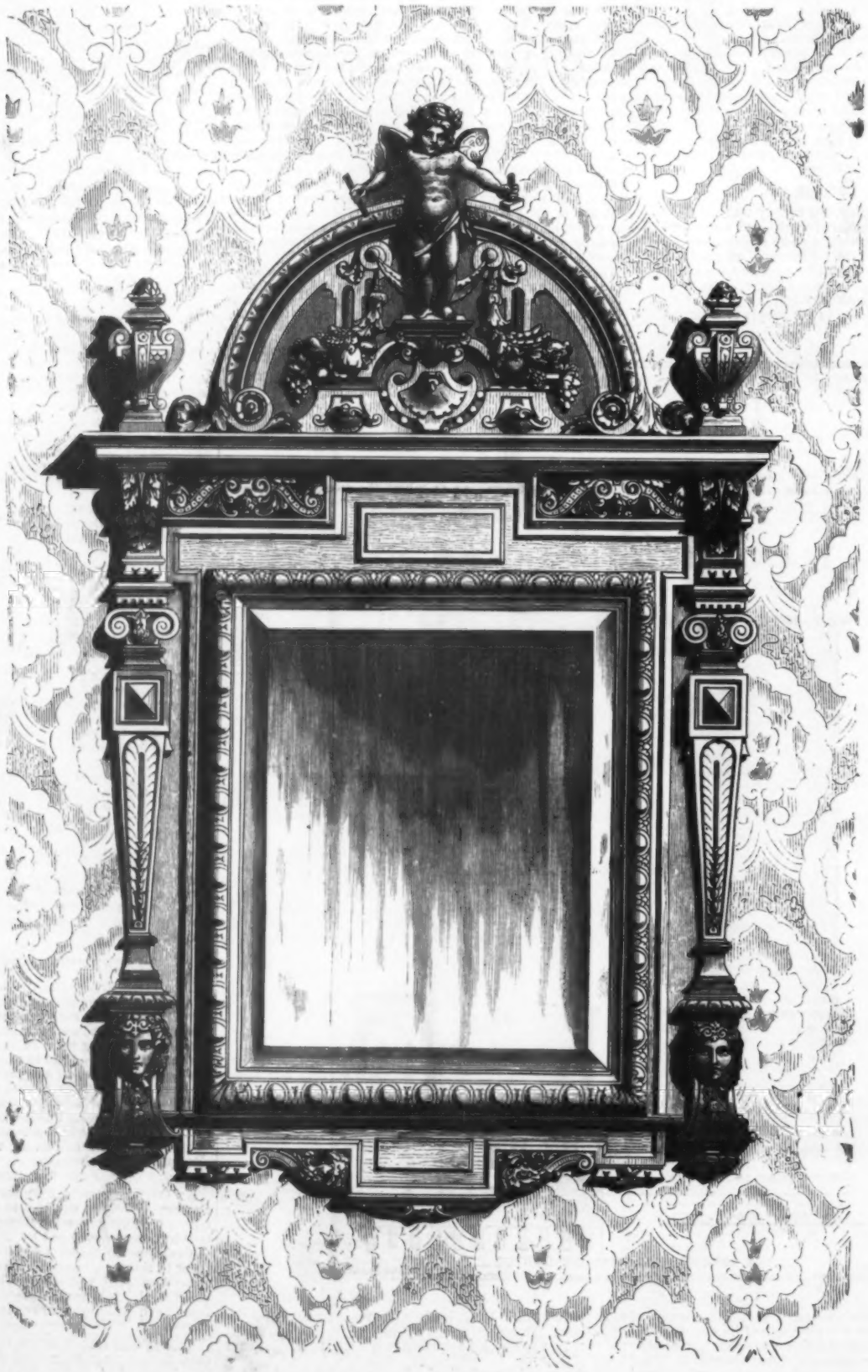
IMPROVEMENT IN SILVERED MIRRORS.

DEBRAY recently announced the production of silvered mirrors free from their usual defects. The first process for silvering glass was suggested by Drayton, in 1840, as a substitute for the expensive and unhealthy tin-amalgam process, then universally employed. It consisted in the reduction of a film of silver upon the plate glass from a solution of ammonio-nitrate, by means of an ethereal oil. After various modifications of the process, Petitjean first established a manufactory of silvered mirrors, in 1856, in Belgium. The glass plates were placed on a cast-iron table, and warmed to 104°, and after being thoroughly cleaned, were flooded successively with a solution containing nitrate of silver, and another containing tartaric acid, which was employed as the reducing agent. The silvering was complete in course of an hour and a quarter, the time varying with the strength of the solutions. After being washed with distilled water, and dried, they were protected by a coat of varnish. A mirror could thus be procured in a few hours, instead of the twelve days required by the amalgam process, and 4 to 5 grains of silver were found sufficient for a surface that required 700 grains of tin and a like amount of mercury by the previous process. Although as a consequence of the above advantages amalgam mirrors are rapidly passing into disuse, still some defects of silvered mirrors prevent their satisfactory use in some cases. They impart a yellowish cast to the image, and the silver is liable to peel off in patches, when they are exposed to the sunlight, and finally, in spite of the protective varnish it is liable to tarnish under the influence of sulphureted hydrogen. As a consequence, although they are less affected by heat than amalgam mirrors, and therefore better adapted to tropical climates, they cannot displace the latter in regions beyond the equator, because they cannot be satisfactorily transported when exposed for months to the exhalations in the holds of vessels. Lenoir, of Paris, has succeeded, however, in entirely eliminating the yellowish tint of the image, and in rendering the mirrors, according to an experience of two years, far less sensitive to sulphureted hydrogen, and at the same entirely unaffected by the sun. This is accomplished by simply flowing the washed silvered mirror with a dilute solution of double cyanide of potassium and mercury, by which an amalgam of silver is instantly formed, which is much whiter and far more adherent than the silver alone. The amount of mercury thus entering into combination varies with the time of contact of the solution with the silver, but in a case observed by Debray it did not exceed 5 to 6 per cent.

SIZING FOR BAGS FOR PACKING GUANO AND PHOSPHATIC FERTILIZERS.—According to an English patent, jute bags are soaked in milk of lime, dried lightly in the air, then immersed in a mixture of 3 parts of oil and 1 of paraffine, and passed through rollers.

HARDENING THIN STEEL ARTICLES, AS SAW-BLADES, SPRINGS, ETC.

DR. HARTMANN recommends the addition of about 1 pound of rosin to the usual hardening mixture, consisting of 4½ quarts of train oil, 2 pounds of beef tallow, and ¼ pound of beeswax, as rendering it suitable for hardening some articles that do not harden sufficiently without it, although the proper amount of rosin can only be determined by experience, since excess of it may render the articles too hard and brittle. After use for some months the mass loses its hardening power, and the trough must be thoroughly cleaned of it before fresh mixture is placed in it. He also recommends another mass, consisting of 95 quarts of spermaceti oil, 20 pounds of melted tallow, 4½ quarts of neat's-foot oil, 1 pound of pitch, and 3 pounds of rosin. The pitch and rosin are melted together, and the other ingredients are then added, and the mass heated in an iron vessel until all the moisture is expelled and the heated mass ignites from a burning splinter held upon it, and the flame is thereupon immediately extinguished by means of a tightly fitting cover. In employing either of these for saw blades, these, after being heated in a suitable furnace, are placed vertically in long troughs filled with the mixture, with the toothed edge, or that intended for the teeth, down, and as soon as they are sufficiently cooled they are removed and wiped with leather until but a film of grease remains upon them, and are then placed flat over a coke fire until the coating ignites, by the



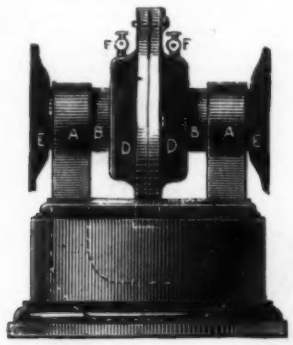
SUGGESTIONS IN DECORATIVE ART.—LOOKING GLASS FRAME IN OAK. DESIGNED AND EXECUTED BY FLACHAT AND COCHET, LYONS.—*From the Workshop.*

burning of which their brittleness is diminished, and the requisite elasticity imparted. If they are to be very hard, but a small portion of the coating is allowed to burn off; but, if softer, it may be allowed to burn until it goes out. If the objects are of greater or less uniform strength, as many springs, the blazing off is repeated upon the whole object, or on portions of it until the desired uniform degree of hardness results. Gunlock springs are sometimes tempered by boiling in oil, by which a very uniform temperature for all portions is secured, and the thinner portions do not suffer from the continued heat of blazing off.

DUPLEX TELEPHONE.

THE principle is that of subjecting a single diaphragm to the action of a magnet and coil on each side of it, and *vice versa*, to affect two magnets and their coils by the one diaphragm. The instrument as constructed is shown in the figure.

A A are the north and south poles of a horseshoe magnet. This magnet is in reality double, and the ends near the poles are bulged out so as to embrace short pieces of soft iron tube marked B B. On the inside ends of these tubes are slipped the usual bobbins containing the wire coils. These cannot be seen, as they are inside the circular box, D. This box is in two halves, screwed together with the diaphragm between them. The outside ends of the tubes carry mouthpieces, E E, of the ordinary form or nearly so. You thus speak through these two pieces of tube which, by being embraced by the magnets, become magnetized themselves by induction. The wires of the two coils are connected to the binding screws, of which there are of course four, though only the two nearer ones, F F, are visible in the figure. Several interesting experiments have been already made with this instrument. It was, in fact,



NEW DUPLEX TELEPHONE.

with this that the phonograph was used as described in my former letter, though not quite in its present form.

If one magnet and coil be properly coupled up to the other so as to bring both into action, it is found that the loudness of the voice at a distant (ordinary) telephone is much greater than when only one coil is used.

If two persons speak or sing simultaneously, one into each mouth-piece, the diaphragm will respond to both sets of vibrations, and both voices will be heard at the distant telephone. So two people at the same time can hear words received from the single distant telephone.

Again, by coupling an ordinary telephone, A, with one coil of the "duplex," and another, B, with the other coil of the duplex (there being no direct connection between the wires of A and B), conversation can be easily carried on between A and B. This would be naturally expected, as the diaphragm receives and "passes on" the vibrations, but in appearance it looks at first sight rather odd.—*English Mechanic.*

MANIFOLD USES OF PRESSED PAPER LETTERS AND ORNAMENTS.

BUNTZEN suggests that multiplied applications might be made in many directions of the letters and ornaments of pressed paper to be had in such variety and so cheap. Thus printers, with but little trouble, could prepare their own plates for printing checks, bills, etc., by arranging the letters, not pasting them, on a smoothly planed board having several thicknesses of well-glazed paper glued upon it, and surrounding the design on three sides with ordinary space lines from 0·07 to 0·12 of an inch thick, laying a board covered with glazed paper upon it, and compressing the whole with screws. Old type may then be melted in an iron spoon, and, when a match dipped into it does not ignite, poured into the mould thus formed. Small metallic castings can not only be readily and cheaply produced from such articles as patterns, but also more tasteful than any in the market. Thus door plates may be cast in brass from patterns formed by gluing the letters on a suitable piece of slate.

DR. BUFF has recently instituted a comparison between the indications of the thermo-multiplier and the radiometer. It was found that "the velocity of rotation of the little wheel is inversely proportional to the heat action of the penetrating rays," and thus, it is claimed, is confirmed the view that the turning of the radiometer is due to an action of heat rays which penetrate the glass. "If the radiometer," says Dr. Buff, "is incapable of measuring a mechanical force of light, it none the less wears its present name with full right. It is a special form of thermometer, only exclusively for heat rays of high refrangibility, whose heating force is proportional to the velocity of rotation of the wheel."

APPLICATION OF ELECTRICITY FOR CHECKING RUNAWAY HORSES.—Faucher, of Paris, has contrived an electrical apparatus for checking runaway horses, which is said to have proved effective in practice. It consists of a magneto-electrical machine concealed beneath the driver's seat, with the crank within reach, the poles of which are connected by means of wires sewed in the bridle and gears, one with the bridle and the other with a small metallic plate beneath the crupper. Turning the crank is said to stop a vicious horse instantly.

PRACTICAL EXPERIMENTS IN MAGNETISM, WITH SPECIAL REFERENCE TO THE DEMAGNETIZATION OF WATCHES.

By ALFRED M. MAYER.

THE extensive uses now made of electro-magnets in telegraphy, in dynamo-electric machines, and in the many practical applications of electro-magnetism, have greatly increased the risks of damage to watches by their magnetization. I have no doubt that in any one of our larger cities there are scores of watches safely packed away in drawers regarded as past recovery from overdoses of magnetism. They are looked upon by their owners as bullion kept in reserve for "a rainy day."

To be aware of the danger is not a sufficient guard against *accidents*. My own experience is a case in point: I had already silenced one watch, saturating it with magnetism by approaching an electro-magnet in my laboratory which had been allowed to remain in action by the person who had that day used it in his experiments. After purchasing another watch, I always took the precaution to place it on my office table before I approached the large electro-magnet of the Stevens Institute of Technology. I always did this, no matter whether the magnet was or was not in action. But one day I was suddenly called out of the room and detained by a visitor for a half hour or more. I took my watch from the table as I passed out of the room. I returned to my laboratory with my mind entirely engrossed with the experiments I had in hand, walked up to the magnet, rearranged the apparatus, and charged the magnet. My watch at the time was not three inches from the pole of this huge magnet! I was only aware of my "accident"—call it, if you will, thoughtlessness about the watch or thoughtfulness about the experiments—when that afternoon I leisurely walked to the station to take a train, and was informed that "it had gone over half an hour." My watch had lost half an hour in about three hours! Persons more cautious than I have had the same experience, for it is impossible, without idiocy supervening, to be constantly thinking of a watch. I have also remarked that out of the two or three dozen owners who have had watches apparently ruined by this same large magnet, each one considered "the other feller" a careless and *thoughtless* person until his turn came to do the same thing, when he was in a really *thoughtful* mood—about something, *which was not his watch.*

My last magnetic accident turned my thoughts to ways of taking the magnetism out of watches. I have succeeded perfectly, and the process which I have finally adopted as the best is so simple that any one can practice it, and that, if you wish, without even detaching your watch from its chain.

Though the process is simple, yet, of course, a knowledge of the elementary facts and laws of magnetism is required to understand *how* it is done; and I know that every intelligent American mechanic really wishes to understand the reasons for performing the operations that he may be called on in practicing any new process.

To render clear to all the operations used in *demagnetizing* (that is, in taking the magnetism out of) a watch, I will assume that I am addressing those who have little or no practical experience as experimenters in magnetism, and also those who wish to be at the least expense in practicing watch demagnetization. I will, therefore, explain the facts and principles of magnetism on which the operations depend, by describing actual experiments made with apparatus which is so cheap and homely that it can be made by any one with a very little trouble and at a trifling expense.

I will at once proceed to show how to make the simple instruments required in our preliminary experiments and in the demagnetization of a watch.

The Magnet may be made out of a piece of a large rat-tail file. The one I have used is 7 inches long and averages $\frac{3}{8}$ of an inch in diameter. There is something either in the quality of the steel or the temper of these files which makes them capable of receiving powerful charges of magnetism. The most powerful magnet I have ever examined is the rat-tail file just spoken of. It lifts several times its own weight. If a large rat-tail file cannot be had, then a piece of Stubs steel, 10 inches long and $\frac{1}{2}$ inch in diameter, must be obtained. This steel rod must be first heated to cherry red, and then lowered gradually, while in an upright position, into a bucket of water. This will render it hard and capable of receiving and retaining a magnetic charge. The file or steel rod is magnetized either by drawing it over the pole of a powerful electro-magnet, or by wrapping around it insulated copper wire, and passing through the wire a current of electricity from a galvanic battery.

The Magnetometer.—We call thus the small magnetic needle suspended in a glass shade by a fiber of silk, Fig. 1. It is made thus: Take a No. 4 or 5 needle, and draw it several times, from point to eye, over the N. end of your magnet. This operation will magnetize the needle, and when suspended from its middle, its pointed end will point toward the north. Now, on to a piece of wood, B, which is 3 inches

Fig. 1.

square, glue and screw the slips, A and A, across its grain, so that it cannot warp. Then on its upper side paste a piece of damp white drawing paper. When this has dried it will be tightly stretched on the piece of wood. Draw on the paper a circle slightly larger in diameter than the length of the No. 4 needle. Divide one-half of this circle off into 180 parts of 1° each; or, if that be too tedious, divide the semi-circumference into ninety equal parts of 2° each. To suspend the needle, you get a skein of floss silk, such as is used in embroidery. This silk is untwisted, and from it you can readily draw a thread formed of a few fibers, which is very delicate and without the slightest twist or torsion in it. To suspend the needle, stick to its middle a small dot of wax. Then press the end of the silk thread into the wax and work the wax over it with the fingers. The other end of the thread is passed through the eye of a large No. 1 or 2 needle. This needle is then passed through a hole in a piece of cardboard, C, placed on top of the lamp chimney, L. The silk thread must be of such a length that when the needle is pushed downward through the hole in C, the magnetic needle, N, may be brought to rest on the paper covering the block, B. Now, on slightly drawing up the needle, S, the magnetic needle, N, will hang just above the Board, B, and will swing round with its pointed, or N., end toward the north of the horizon. After many oscillations the needle will come to rest and will point in a direction which is called the *magnetic meridian*. This direction is different for different places. Here, in New York, it makes an angle of 7° with the true north and south line, and the N. end of the needle points 7° to the west of the true north. This pointing of a suspended needle away from the true N. is called its *magnetic declination*, or magnetic variation. In New York and its vicinity the magnetic declination is 7° west.

In addition to the magnet and magnetometer the experimenter will need the following materials:

Three pieces of soft iron. One piece 12 inches long and $\frac{3}{8}$ inch in diameter; another piece, 3 inches long and $\frac{1}{4}$ inch in diameter; a third piece, $1\frac{1}{4}$ inch long and $\frac{3}{8}$ inch in diameter. These pieces of iron should be made very soft by heating them to bright redness and then allowing them slowly to cool in hot ashes.

A piece of steel wire, 6 inches long and $\frac{1}{16}$ inch in diameter.

Iron filings, made from soft iron and passed through a fine sieve.

Pieces of window glass. Two 12 inches by 6, and two pieces 6 inches square.

A small bottle of spirit varnish, such as photographers put over their negatives.

Needles, nails, and tacks of various sizes.

With the above simple and cheap things a great many interesting and beautiful experiments can be made; and we will now show how to obtain from these homely instruments much information that is really sound and useful.

Experiments showing in what a Magnetic Substance differs from a Magnet.—Place the magnetometer on the table and

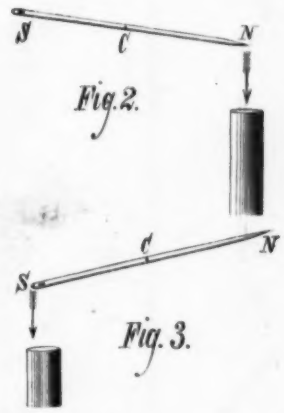


Fig. 2.

Fig. 3.

allow the magnetic needle to come to rest. Now take the piece of soft iron 3 inches long and bring it slowly up to the magnetic needle, always keeping the piece of iron pointing toward the point of the needle, as shown in Fig. 2. You will observe that the point of the needle moves toward the iron, turning around its center, C, in the direction shown by the arrow.

Slowly and steadily draw away the piece of iron. As you do so the needle slowly turns on its center, C, and comes again into the magnet meridian. Now bring the piece of iron up to the eye end of the needle, and you will see that this end turns toward the iron in the same manner as did the point of the needle in the previous experiment. Thus we find that a piece of soft iron attracts either end of the magnetic needle. Each end moves toward the iron. If this be so, it necessarily follows that if you point the piece of iron directly toward the center of the needle and bring it up to the needle in this position, keeping care always to have the length of the piece of iron at right angles to the length of the needle, the needle will not move, but remains steadily pointing in the magnetic meridian. Each end of the needle is equally attracted toward the iron, and as each end tends to turn in the direction shown by the arrows in Fig. 4, it remains at rest under the action of two equal forces tending to rotate the needle in opposite directions.

Now we will make some experiments similar to those just described, but differing in this: we use a magnetized No. 1 sewing needle instead of the piece of soft iron. Take a No. 1 sewing needle and draw it from point to eye over the N. end or pole of your rat-tail file magnet. You will, by this operation, have converted the needle into a magnet, and if you suspend it, as I wish you now to do, like the needle of your magnetometer, you will find that *it points in the magnetic meridian with its point toward the north.* The ends of magnets, or, more accurately speaking, certain points in the center of magnets and *near* their ends, are called *the poles of the magnet.* To distinguish these two poles, they are respectively called north pole or south pole, corresponding to the end of the needle which points toward the north or south geographic pole. The points of our magnetized needles are, therefore, north poles, while their eye ends are south poles.

Bring the No. 1 needle up to the needle of the magnetometer, with its point toward the point of the magnetometer needle and with its length always at right angles to the magnetic meridian, as shown in Fig. 5. The N. pole of the needle moves away from the north pole of the No. 1 needle, and we here have *repulsion* instead of attraction, as we had when the piece of iron was placed in the same position. Now point the north pole or point of the No. 1 needle toward the eye end, or south pole, of the magnetometer needle, as shown in Fig. 6. In this position of No. 1 needle, the S. pole of the suspended needle moves toward the N. pole of the No. 1

needle. So in this experiment we have attraction of the S. pole toward the N. pole. Thus we have found out that the north poles of magnets repel each other, while the north pole of one magnet attracts the south pole of another magnet. This being the case, it follows that the No. 1 needle,

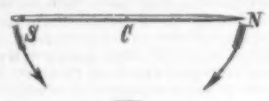


Fig. 4.

Fig. 5.

attracting the S. pole of the suspended magnet and repelling its N. pole, must, when pointed at right angles to the suspended needle and directed toward its center, C, cause the suspended needle to rotate, its S. pole moving toward the point of the No. 1 needle, as shown in Fig. 7.

Fig. 6.

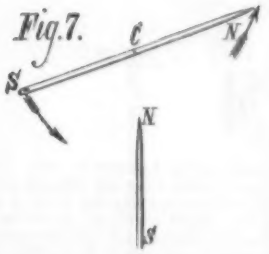


Fig. 7.

The experimenter must now compare this experiment with the similar one with the piece of iron. The iron when pointed toward the center of the magnetic needle did not rotate it, but when the magnetized needle is placed in the same position the suspended needle rotates and its N. pole moves away from the N. pole of the No. 1 needle.

Let us vary these experiments by pointing the eye end, or south pole, of the needle first toward the N. end and then toward the south end of the magnetometer needle, and then

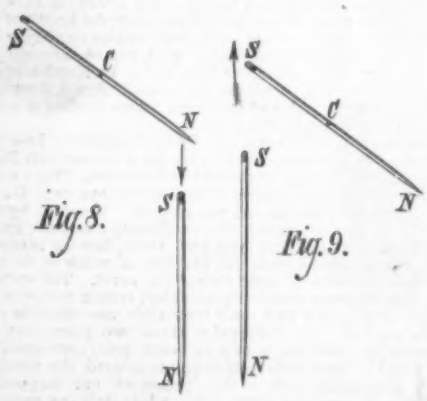


Fig. 8. Fig. 9.

toward the center of this needle. Figs. 8, 9, and 10 show the results of these experiments. They differ from those of Figs. 6, 7, and 8 in this: the south pole of the magnetized No. 1 needle acts on the suspended needle in place of the north pole. The results are as follows: The S. pole of the No. 1 needle repels the S. pole of the suspended needle and attracts its N. pole; and consequently when its eye end is pointed toward the center, C, of the suspended needle the latter has its N. end pulled toward the No. 1 needle and its S. end repelled. It necessarily turns around its center, C, its N. pole moving toward the eye end or S. pole of the No. 1 needle.

These are very simple experiments, yet they have already given us the knowledge of an important law, which may be summed up thus:

Like poles repel each other, while unlike poles mutually attract each other

These experiments also give us a practical and easy method

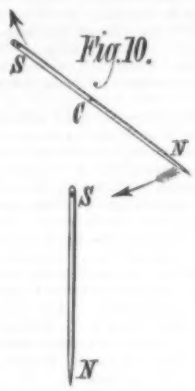


Fig. 10.

of determining whether a body is merely *a magnetic substance* like our piece of soft iron, or a piece of nickel or cobalt; or is a magnet like our No. 1 magnetized needle.

Each end of a bar of a magnet substance attracts either the N. or S. pole of a suspended magnet; but *a magnet has poles*, and one of its ends acts to attract one end of a suspended magnet, while the other end of the magetic bar will repel the same end of the suspended magnet. Hence to tell whether a certain bar is a magnetic substance or a magnet, we place it with its length at right angles to a suspended magnet and pointing toward its center. If in these circumstances the suspended magnet remains at rest, then the bar is formed of a magnetic substance, or one which has no action whatever on a magnet. To determine whether the latter is the nature of the bar, we bring one of its ends near an end of the suspended magnet; if the latter remains at rest, then the bar is formed of a substance which has no sensible magnetic action on the suspended needle. If, however, the suspended magnet turns when the bar is placed at right angles to its length, then the bar is a magnet, and the end of it which is toward the needle is the pole which is of the same name as the pole of the suspended magnet which moves away from the bar.

With the magnetometer we may, therefore, determine the name of the pole of a magnet by the direction in which the magnetometer needle moves, and we can compare its intensity with another magnet by observing the number of degrees of the circle over which the needle rotates.

These experiments on the mutual attractions and repulsions of magnets may be modified in a very pleasing manner

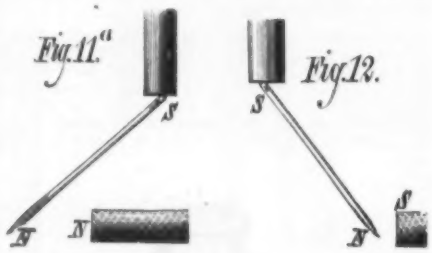


Fig. 11a. Fig. 12.

by allowing a No. 1 magnetized needle to adhere from the end of a piece of soft iron, and approaching to the free end of the needle first one pole and then the other of the magnet. Figs. 11*a*, 12, 13, and 14 may serve to clearly show the different phases of these experiments without further explanation.

Experiments in Magnetic Induction.—Pour some iron filings on a sheet of paper and roll your rat-tail file in them. Lift the magnet from the paper and you will see that the filings stick in the form of bristles or brushes to the two ends, and at some distance from the two ends of the magnet, but to the middle portion of the magnet no filings adhere, as is shown in Fig. 11.

Stick the end of the piece of soft iron in the filings; you will see that they do not adhere. Now stand the piece of iron upright in the filings and bring the rat-tail file down on the upper end of the iron. Lift the magnet, and the iron, you will find, adheres to the magnet; also, you will observe that the iron itself is now magnetic, for the filings adhere to it, as shown in Fig. 15.

If you take hold of the piece of iron with one hand and then detach the magnet, lifting it above the iron, you will see that the iron loses its magnetism, for the filings fall when the magnet is removed to a distance from the iron. Yet it is not necessary that the magnet should actually touch the iron to render it magnetic, for you will find that the iron will attract the filings and cause them to adhere to it even when the magnet is held at a short distance above the end of the iron, as shown in Fig. 16, though the quantity of iron filings which it is capable of holding, and consequently the strength of its magnetism, is less than when the iron adhered directly to the magnet.

The above experiment is modified in an interesting manner by using different sized nails, brads, and tacks in place of the filings.

In this experiment, represented in Fig. 17, the magnet has directly adhering to it a large nail. This nail is thus made

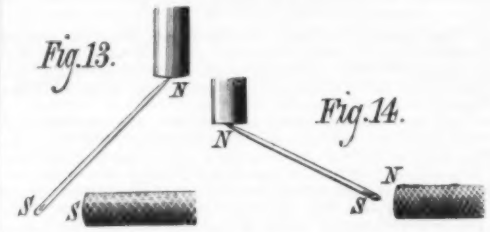


Fig. 13. Fig. 14.

a magnet, and it in turn holds up a smaller nail, and this a yet smaller one, which in turn supports a brad, and this brad a smaller one, and to this sticks a tack, and to the tack adheres some iron filings. Each nail in turn acts on the nail or tack which adheres to it, just as the magnet acts on the large nail directly adhering to it

Thus it is seen that the magnet *induces* the iron to become a magnet like itself when it touches the iron or is held near it; hence this action of a magnet on soft iron is called *induction*.

We will now repeat these experiments in induction, but we will use a piece of steel in place of the soft iron. Select a short thick sewing needle that contains no magnetism. Of this you may be sure if, when the needle is pointed toward the center of the magnetometer needle, and at right angles to its length, it does not cause the latter to rotate. If the needle, when dipped in iron filings, does not cause them to adhere to its ends, it will be free enough of magnetism for our experiments.

Having tested the needle and found it free of magnetism, you now hang it to the end of the rat-tail file magnet and bring its free end into the filings. They now adhere to the needle, as shown in Fig. 18.

Hold the needle between the fingers of one hand and remove the magnet to a distance with the other hand. You

Fig. 11.

Fig. 15.

Fig. 16.

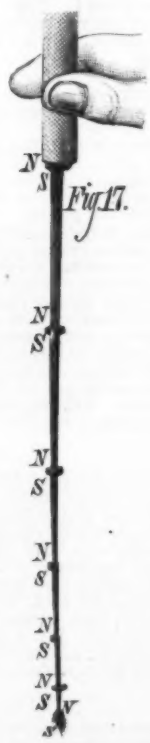


Fig. 17.

now see that the needle behaves differently from the piece of soft iron, for when the magnet was removed from the latter the iron filings dropped from its end, but in the case of the needle the filings remain suspended. In other words, the iron is only temporarily magnetized by induction; that is to say, it remains magnetized only while in contact with the magnet. On the other hand, the needle is permanently magnetized by induction; that is, it remains magnetized after

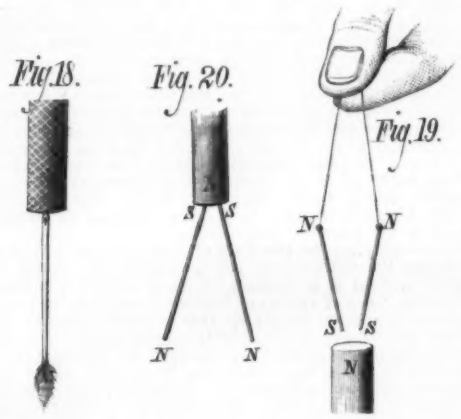
the magnet has been removed from it. This difference in the after effects of induction on soft iron and steel is best observed in the following experiment:

Take a piece of the softest iron, and having ascertained that it is entirely free of magnetism, draw it repeatedly over the end of the magnet; if the iron is really soft you will find that even repeated stroking on the magnet cannot give it the power of attracting the filings. However, generally the iron will retain a slight, though often very slight, amount of magnetism, and will cause a few particles of filings to adhere to it. Now perform the same experiment with a large sewing needle, and observe how powerful a magnetic charge has been given to it. When rolled in the filings large tufts adhere to its ends, surprising those who have never seen before how strong a magnet may be thus made of a large sewing needle.

This retention of a magnetic charge by steel enables us to readily fashion magnets of any form and size. If steel or some other easily worked body had not this property we would be obliged to construct our mariner's compass needles out of the hard and brittle calamite or loadstone. Indeed, it would be difficult to select from the whole range of the special properties of matter one more valuable to man, or more necessary to his present high and widely spread civilization, than this one of the capability of steel to receive and retain the properties of the loadstone.

Further Experiments in Magnetic Induction.—Let us, by means of other simple experiments, examine more minutely into the nature of this magnetic induction.

Take two pieces of very soft iron wire and suspend them by silk fibers, as shown in Fig. 19. Hold the ends of the fibers separated, between the thumb and forefinger, so that the wires may hang a quarter of an inch or so apart. Now bring them slowly down toward the N. end of the magnet, as shown in Fig. 19. They now no longer hang parallel to each other,



but are inclined, the upper ends of the wires repelling each other, so that the two suspending threads are forced outward and no longer hang vertically. This repulsion between the upper ends of the soft iron wires is caused by their having the same magnetic polarity. We have already seen that like poles mutually repel. (See experiments described in Figs. 5 to 14.) If the N. pole of the magnet is pointing upward, as shown in Fig. 19, then the lower ends of the suspended iron wires are of S. polarity and their upper ends are of north polarity.

The experiment just described may be modified by simply

holding the two wires parallel to each other between the thumb and forefinger and bringing their ends to touch the end of the magnet. They will adhere to the magnet, and on relieving the wires between the thumb and finger they will at once fly apart, from their mutual repulsion, as shown in Fig. 20.

Take seven pieces of iron wire, each about 1 inch long, and run them through small corks, about ¼ of an inch long and $\frac{3}{16}$ inch in diameter. Throw these pieces of wire into a bowl of water and they will float vertically. They will come to rest at various haphazard positions on the water. Evidently there is no order in their arrangement. Now take your rat-tail file magnet and, holding it in a vertical position, bring it over the water in the bowl. At once the pieces of wire sail toward the magnet, and after many motions among themselves, they at last take up the definite figure of a hexagon with a floating wire in its center, as shown in Fig. 21

This is a beautiful illustration of magnetic induction, and this experiment tells the whole story when viewed in the light which another gives, and which will be at once described before speaking further of the one just made.

Take seven sewing needles; "Milward's No. 6 betweens" are good for this experiment. At the N. Y. Cork Cutting Co., 45 Fulton street, New York, you may buy a gross of corks, of ½ inch in length and $\frac{3}{16}$ inch in diameter, for 10 cents. Magnetize each needle by drawing it from point to eye end over the N. end of your rat-tail file magnet. Then run each needle through the center of a cork made by halving one of the corks just described. In other words, the corks which will float these needles are ¼ inch long and $\frac{3}{16}$ inch in diameter. Now throw these needles in the bowl of water. They repel one another, and if time enough be given them they will at last reach the edge of the bowl and will arrange themselves at equal distances apart around the border of the water. They do so because when floating upright their like poles are opposed to each other, as shown in Fig. 22, and these like poles mutually repel.

While the needles remain on the border of the water in the bowl, bring down vertically the rat-tail file over the center of the water, with its N. pole pointing downward. The magnetic needles at once rush toward the middle of the bowl, and after moving about each other for a while they end by forming the same regular geometric figure of the hexagon, with a needle in its center, as happened in the experiment with the floating iron wires, shown in Fig. 21. In the experiment with the magnetic needles we know the exact magnetic conditions of the experiment. We know that the needles are magnets, and that their south poles are pointing upward and their north poles are down in the water. The like poles of these needles being opposed, they mutually repel, and keep apart till the N. end of the magnet has been brought over them; then this strong north pole attracts the upper or south poles of the needles, and they draw toward the N. pole of the magnet. In other words, the attraction existing between the N. pole of the magnet and the south poles of the needles is stronger than the repulsive force existing between the needles. The needles therefore move toward the magnet and approach one another till their mutual repulsive actions keeping them apart just balance the attraction of the magnet which tends to bring them together.

If the magnet be held at rest, the figure of the hexagon remains at rest; but if the magnet be slowly raised, the hexagon enlarges as the magnet goes further off from the hexagon, for in this case the attractive action of the magnet diminishes. If, however, the magnet approaches the hexagon, the latter shrinks in size, for the attractive force of the magnet on the hexagon increases, and the needles approach till their increased mutual repulsion exactly equals the increased attraction exerted by the magnet on them when the magnet is nearer the hexagon.

If the reader's interest should be excited by the description of these new experiments in magnetism, he will find in the SCIENTIFIC AMERICAN SUPPLEMENT, No. 129, an extended description of them and of the phenomena which they may serve to explain and illustrate, with a full set of the various figures found by different numbers of floating magnets.

Now let us return to our experiments with the floating iron wires. These wires were not magnetized, therefore they did not repel one another when thrown into the bowl of water. They differed from the magnetic needles in this, and hence did not drive one another toward the border of the bowl. But when the magnet was brought over them they acted precisely like the magnetic needles, and formed the same regular hexagon with a floating wire in its center. The force acting on the wires and the needles was the same. It was the N. pole of the magnet. We know that the needles will only move toward the N. pole of the magnet when their south poles are upward and their north poles are down in the water. The wires did the same, and we therefore have a right to assume that when they moved toward the N. pole of the magnet their upper ends were made south poles by the inductive action of the magnet, and their lower ends under the water, were made north poles by the same action.

We can now understand the condition of the polarity in the magnetic chain formed by the suspended nails, brads, etc., in the experiment shown in Fig. 17. To the N. pole of the magnet is attached a nail. The end of the nail touching the magnet is made its south pole by induction, while its other end is made its north pole. This nail now acts just like the magnet which magnetized it, and the nail in turn magnetizes by induction nail No. 2, and this nail No. 3, and so on to the end of the magnetic chain, which is terminated by the magnetized iron filings.

Experiments which show Something about the Nature of a Magnet.—Take the piece of steel wire, six inches long and one-sixteenth of an inch in diameter, mentioned among the articles required in our experiments; score this piece of wire at short distances apart, by filing it around with a sharp file. Now heat the wire to a cherry red, and then plunge it vertically into water. It will now be quite hard, and may be readily made into a magnet by drawing it over the pole of your rat-tail file magnet. Paste a small piece of paper around one of the ends of the steel wire before you magnetize it, and then, if you draw the wire over the N. pole of the magnet, from the papered end to the unpapered end, the papered end of the wire will have north polarity, as may be shown by applying the wire to the magnetometer. The magnetic condition of the wire having been found out, we begin by snapping the wire into small pieces, which is readily done, for the scores on the wire determine where it will break. Place each piece on the table as it is separated from the wire and with its ends pointing in the same direction which they had when it formed part of the wire. Examine each of these pieces in succession. They will be found to be perfect magnets, with N. poles turned all one way, their south poles turned in the other direction. This examination may be made by means of the magnetometer. The fact that each piece is a magnet may also be readily shown by rolling it in iron filings, when it will be found that the filings adhere to the ends of the piece of wire just as they did to the large magnet. See Fig. 11.

Fig. 23 gives a view of the pieces of wire placed end to end just in the position they had when they formed parts of the steel wire. We see that each piece is a perfect magnet, and that the north poles of these pieces all point to the right and their south poles all to the left. But each of these little fragments may be broken into two, and so on; and as far as the subdivision may be carried, it has been found that each minute fragment is a perfect magnet, with one of its ends a south, and the other a north magnetic pole. In imagination we may conceive of this subdivision carried so far that one of the particles thus reached may be invisible to the unaided eye. Indeed, nothing prevents us from logically assuming that even if a molecule of the steel should be reached it would be found to be a perfect magnet.

An Experiment with a Magnet formed of Steel Filings Packed in a Paper Cylinder, is interesting when studied in connection with the experiments just made, and will serve to give us further information as to the nature of a magnet.

Take a piece of letter paper, and having wrapped it several times around a lead pencil, paste the free edge of the paper on to that wrapped around the pencil. After the paste has dried you may draw out the lead pencil, and you will then have a tube made of paper. Cork one end of this tube, or you may close it by doubling over the paper at its end and gluing. Fill this tube with steel filings, and then close the other end of the tube. This tube, filled with steel particles, may be formed into a magnet by drawing it over the pole of your rat-tail file magnet. After you have performed this operation several times, present the tube to the magnetometer, and you will find one of its ends is a north, while the other is a south pole. Having thus satisfied yourself that it is really a magnet, shake the tube so that the positions of the particles of steel filings are changed. On testing the tube at the magnetometer it will be found that much, probably all, of its magnetism has gone from it. If it has not all disappeared it can be made to do so by repeated shaking of the tube. This experiment shows that not only must each particle or even molecule of a steel bar be a perfect magnet, but it also shows that these magnetized particles must be arranged in a definite order, that is, with all their N. poles pointing in one direction and their south poles in the opposite direction, so that the body, as a whole, may obtain and retain its magnetic polarity. Before the year 1600, when William Gilbert, the physician to Queen Elizabeth, made the celebrated experiment of breaking a magnet into many parts and testing the polarity of each piece, it had been thought that all of the north polar magnetism was contained in one end of the magnet, while the other end of the magnet held the south polar magnetism.

Interesting Experiments may be made with magnets acting inductively on a great number of iron grains spread on a surface placed over the magnet. We may thus form an idea of how this magnetic influence extends itself into space.

Take a piece of cardboard about one foot long and six inches broad. Support this at its corners on blocks of wood a little thicker than the diameter of your rat-tail file

magnet. Place the latter under the cardboard. Now lift the cardboard off its supports and place it to one side on the table. Through a fine sieve sift soft iron filings evenly, and not too thickly, over the cardboard. Lift it up carefully and place it over the magnet. A slight bristling of the filings is all that you will observe of the action of the magnet; but on vibrating the cardboard, by letting fall vertically on it a piece of copper wire, or by tapping it gently with a lead pencil, you will observe curious motions among the grains of filings. They will finally arrange themselves over the magnet in the curves shown in Fig. 24.

Fig. 25 shows the arrangement taken by the iron filings when they are placed on a card and vibrated over the end of a round magnet, the magnet being held in a vertical position under the cardboard.

Fig. 26 are the lines formed over the end of a magnet. Figs. 27 and 28 respectively show the actions of magnets with their unlike and like poles opposite each other.

Fig. 29 is interesting showing the arrangement of the lines of filings produced on a surface when under it a magnet, 216 millimeters long and 12 millimeters in diameter, is acting inductively on a cylinder of soft iron, 32 millimeters long and 10 millimeters in diameter. In April, 1871, I published in the *American Journal of Science*s a method I had invented for permanently fixing these lines of iron filings (or *magnetic spectra*, as they are often called) on plates of glass. When thus permanently attached these plates were used as negatives from which a series of photographs were printed, exactly as a photographer prints from an ordinary photographic negative. The admirable engravings of magnetic spectra given in this article were made by a photo engraving process directly from the glass plates made by me in 1871. These glass plates carrying the magnetic spectra I have also used for several years as slides in the lantern, in order to exhibit them before large audiences and college classes.

The following is the method of permanently attaching these magnetic figures to glass. A clean plate of thin glass is coated with a film of hard varnish by flowing over it the spirit varnish used by photographers in coating their negatives. If this is not handy, then a solution of shellac in alcohol will do nearly as well, only the latter requires more heating to cause the iron filings to adhere to it. The varnish is poured on one end of the plate, and then caused to

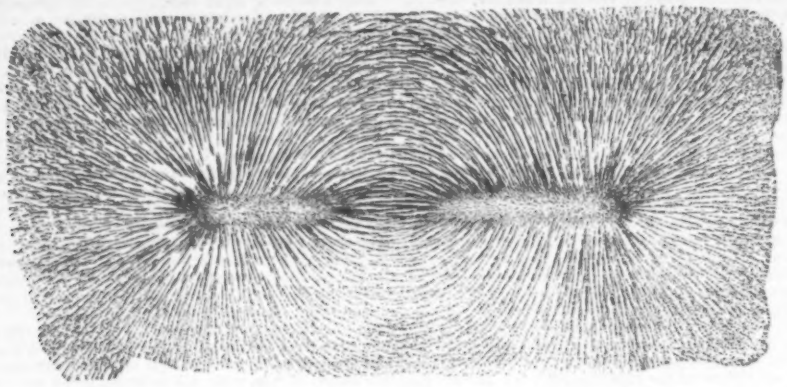


FIG. 24.—MAGNETIC CURVES AS SHOWN BY IRON FILINGS.

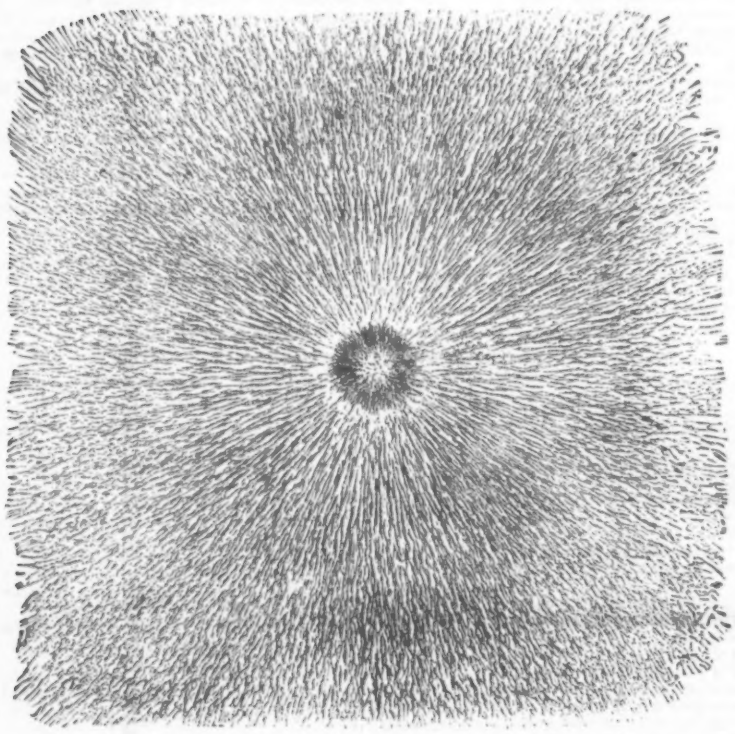


FIG. 25.—ARRANGEMENT OF FILINGS OVER THE END OF A ROUND MAGNET.

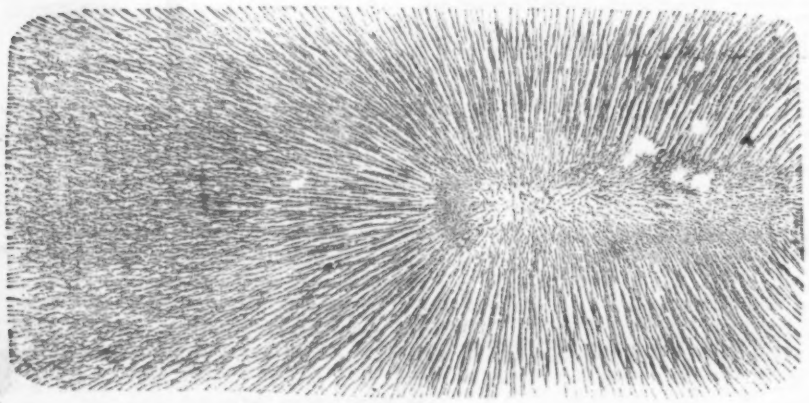


FIG. 26.—LINES FORMED OVER THE END OF BAR MAGNET PLACED PARALLEL WITH ITS PLATE.

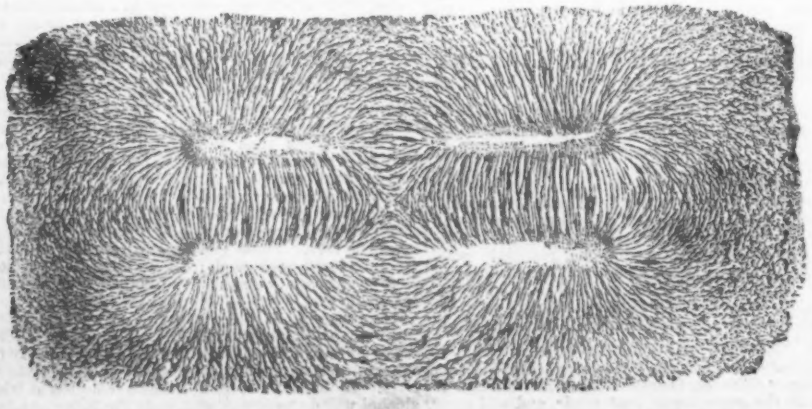


FIG. 27.—MAGNETIC CURVES—UNLIKE MAGNETIC POLES OPPOSITE EACH OTHER.

cover the entire plate with an even film, by tilting and draining the plate just as a photographer does when he coats his plate with collodion. After the varnish has dried to a hard film the plate is placed, varnished side up, over the magnet or magnets, with its ends resting on slips of wood, so that the under surface of the plate just touches the magnet. Fine iron filings obtained from Norway iron, which has been repeatedly annealed, are now sifted uniformly over the plate, and then the magnetic curves are developed by letting fall on the plate vertically at different points a piece of copper wire. The vibrations of the plate momentarily detach the filings from its surface, and at these moments the magnet arranges them in obedience to its inductive action on them. The plate is now lifted from the magnet, being careful to hold it always in a horizontal position, and either placed with its ends resting on bricks over a hot stove, or it is heated over a gas stove. The film of varnish is thus melted, and the filings sinking into it are permanently fixed there after the varnish has cooled. If any filings should remain unattached, they are removed from the plate by letting its edge fall squarely on the table.

The lines forming these magnetic spectra were called "lines of magnetic force" by Faraday. He also devised the term "magnetic field." *A magnetic field* may be defined as any space at every point of which exists a finite magnetic force; while *a line of magnetic force* is a line drawn through a magnetic field in the direction of the force at each point through which it passes. Before the time of Faraday natural philosophers were satisfied with the mere statement that magnets acted at a distance, and followed generally the same law as ruled in the action of gravitation throughout the celestial spaces, that is to say, that the intensity of the magnetic action decreased inversely as the squares of the distances from the pole of the magnet; but Faraday, in the words of Professor Maxwell, "in his mind's eye saw lines of force traversing all space where the mathematicians saw centers of force attracting at a distance; Faraday saw a medium when they saw nothing but distance; Faraday sought the seat of the phenomena in real actions going on in the medium; they were satisfied that they had found it in a power of action at a distance impressed on the electric fluids." Faraday discovered the general laws which rule the behavior of bodies in the magnetic field. When the magnetic field is uniform—that is, when the lines of magnetic force are parallel—magnetic bodies place themselves in the direction of the lines of force; but when the magnetic field is not uniform, magnetic bodies (like iron, nickel, cobalt, etc.) tend to go from weaker to stronger places of magnetic action, while diamagnetic bodies (like bismuth, borate of lead, etc.) tend to go from stronger to weaker places in the magnetic field.

The conception of the lines of force and the magnetic field, and the statement of the laws ruling the action of bodies in field of a magnet, "formed," says Sir William Thomson, "one of the most brilliant steps made in philosophical exposition of which any instance exists in the history of science. . . . Mathematicians were content to investigate the general expression of the resultant force experienced by a globe of soft iron in all such cases; but Faraday, without mathematics, divined the result of the mathematical investigation, and, what has proved of infinite value to the mathematicians themselves, he has given them an articulate language in which to express their results. Indeed the whole language of the magnetic field and lines of force is Faraday's. It must be said for the mathematicians that they greedily accepted it, and have ever since been most zealous in using it to the best advantage. Indeed, much of the scientific work of Thomson, and nearly all of Maxwell's celebrated 'Treatise on Electricity and Magnetism,' may be regarded as translations of Faraday's conceptions into the language of mathematical analysis."

Let us now make a few experiments on these lines of magnetic force. We will thus be led to some remarkable results. Form a small magnet of a piece of sewing needle about one quarter of an inch long. Suspend this with a filament of the floss silk. Having formed a magnetic spectrum, and with the magnet remaining undisturbed under the cardboard or glass, bring the little magnet over one of the lines traced out by the filings. Move the suspended magnet over this line, and you will observe that the length of the needle always lies in the direction of the line, no matter where the needle may be placed over this line. Faraday, from this fact indeed, gave his definition of a line of magnetic force as "that line which is described by a very small magnetic needle, when it is so moved in either direction correspondent to its length, that the needle is constantly a tangent to the line of motion."

"The Earth itself is a Great Magnet." These are the words which may be said to form the text on which the illustrious William Gilbert wrote his work "De Magneto," or "On the Magnet," in 1600; and he certainly gave proofs of the truth of his statement, which, when viewed in the light of the knowledge which he himself discovered, forms an era in the history of the experimental sciences. If the earth be a great magnet, then it also must have its lines of force surrounding it and stretching out into space. At first sight it would seem difficult to prove this, for its proofs seem to require the existence of some immensely extended, light, movable, and luminous matter surrounding the earth, on which its magnetism can act, and by this action render manifest the direction of its lines of force. Now it so happens that such evidence is not wanting. All of our readers, I imagine, have seen those luminous and movable columns which form the aurora borealis. They appear to start from some level above the northern horizon, and stretching upward appear to converge at some point high up in the heavens. Sometimes this point is higher, sometimes it appears lower, according to the latitude of the observer.

Now we have seen that the magnetic needle always places itself in the direction of, or, more correctly speaking, at a tangent to, a line of magnetic force, and it has been often observed that a magnetic needle, when suspended so that it can place itself in any position, either up, down, to the right or to the left, always places itself parallel to those luminous columns. This observation has been repeatedly made in various latitudes, and its general truth is established. The vast luminous rods, which are often 500 miles and over in length, actually trace out in space the earth's lines of magnetic force.

That the earth is a great magnet, you may at any time show to yourself and your friends by a few simple but very charming experiments.

Take the piece of iron, one foot long and three eighths of an inch in diameter (which I mentioned among the things required in our experiments), and heat it to a dull red heat in the fire, and then allow it slowly to cool in the hot ashes. In cooling the rod it should be placed with its length in an east and west direction. After the rod is cold paste a piece of paper around one of its ends. Take it carefully in the

hand and avoid letting it fall or giving it a blow. Bring the papered end of the rod up to the needle of the magnetometer, and point it at right angles to the length of its needle and directly toward its center. You will observe that the needle remains stationary as long as the iron rod points *in a horizontal direction* toward its center. This is so because the iron is devoid of magnetism, and hence attracts the north end of the needle with a force equal to that with which it attracts the south end of the needle.

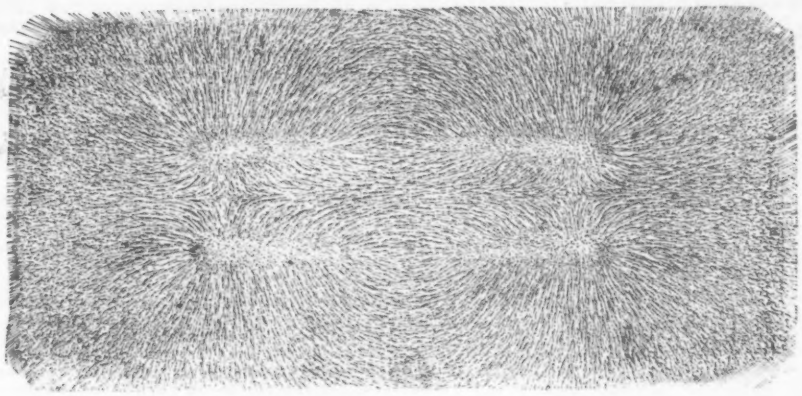


FIG. 28.—MAGNETIC CURVES—LIKE POLES OPPOSITE EACH OTHER.

Now observe what takes place when we slowly lift up the end of the rod furthest from the magnetometer. The south pole of the needle at once swings around toward the iron rod. This cannot be owing to the inclined position of the iron, because, even in this inclined position, it is symmetrically placed in reference to the needle, and should not on this account cause the latter to turn. Evidently the iron rod has become magnetic from this change of position. The mere tilting up of its end has made it a magnet. A temporary magnet, it is true, for on slowly lowering the iron into a horizontal position the needle slowly turns into the magnetic meridian, and is then apparently indifferent to the presence of the iron rod.

Now bring the unpapered end of the rod up to the magnetometer and repeat the above experiments. The needle again turns its south end toward the rod when the latter is tilted upward. This shows that the magnetism of the rod depends alone on its position, and that end which is down is always of north magnetic polarity. It has also been found —and you can prove it for yourself—that when the rod is held inclined in the meridian, with its upper end leaning away from the north, so that it is at an angle of about 70° with the horizon, it has the most powerful magnetism that can be given to it by this means.

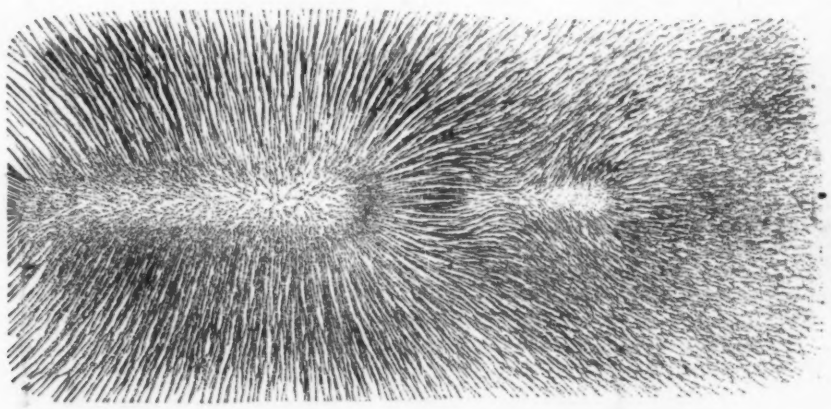
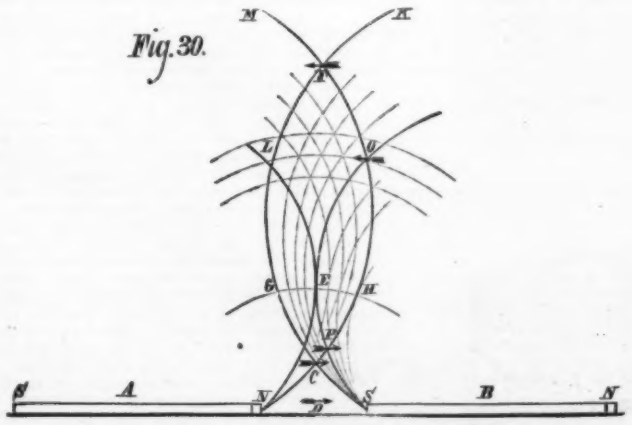


FIG. 29.—CURVES SHOWN BY A MAGNET ACTING INDUCTIVELY ON A CYLINDER OF SOFT IRON.

All of the above curious facts are explained if we consider the earth itself as a great magnet, with its south magnetic pole situate somewhere near the north geographic pole, and with its north magnetic pole placed somewhere near the south geographic pole. If you carry your small suspended magnetic needle over the length of a magnet, you will observe that the north end of the needle will point downward when it is over the south pole of the magnet, and that the south end of the needle will point downward when it is over the north pole of the magnet; while, when over the center of the magnetic bar, the needle takes up a horizontal position. In the same manner acts a freely suspended magnetic needle when carried over the surface of the earth along a meridian.

In a far northerly latitude, on the western coast of Boothia, Sir James Ross, in 1831, found that the magnetic needle pointed directly downward, with its north pole toward the center of the earth. He inferred that he then stood on the termination of a line drawn from the earth's center through its magnetic pole to his feet. Subsequently this bold mariner undertook another voyage of discovery in search of a similar point on the southern hemisphere, and in 1841 succeeded in reaching south latitude 76° 12', on Victoria Land, when the south end of the needle pointed downward and made an angle of 88° 40', with the horizon. He concluded from this and other observations that the position where the needle would be vertical was about 160 nautical miles distant. From these and other magnetic observations made in the Antarctic seas, it is supposed that the magnetic pole of the southern hemisphere must be somewhere about south latitude 70°, and near the meridian of 125° east of Greenwich. This would bring the position of the magnetic pole somewhere on the territory discovered by our countryman Wilkes. The exact position of this point, however, is not known, for no explorer has ever reached it. Also, it has been well ascertained that along an irregular line, situated on the equatorial belt of the earth, the needle has a horizontal position, just as it has when placed midway between the poles of an artificial bar magnet. This irregular equatorial line is called the earth's magnetic equator.

Fig. 30.



LINES OF MAGNETIC FORCE.

These facts are all explained by conceiving the earth as a huge magnet, and if the earth be a magnet, it also follows that the soft iron rod, when held upright in the southern hemisphere, will have its lower end of south magnetism, while the same end in the northern hemisphere, we have ourselves found, is always of north magnetic polarity. We cannot travel over the earth and test this conclusion for ourselves, but I once found in the Transactions of the Royal Society of London a paper headed "*On the tendency of the Needle to a piece of Iron held perpendicular, in several climates. By a master of a ship, crossing the Equinoctial line. Anno* 1684." Let the mariner give his own account of his experiments, and we will see that his statements show that when you cross the magnetic equator the lower end of the upright iron rod changes from north to south magnetic polarity: "All the way from England to 10° north latitude, the north end of the needle tended to the upper end of the iron, and the south point to the lower end, very strongly. . . . In latitude 8° 17' south, and meridian distance from the Lizard 17° 35' west, the north point of the needle would not respect the upper end of the iron; but the south point would still somewhat respect the lower end. . . . In latitude 29° 25' south, and 18° 10' west, from the meridian of the Lizard, the south point of the needle respected the upper end of the iron, and the north point the lower end strongly."

On the "Magnetic Neutral Line."—There has recently appeared much discussion about the existence of a position of neutrality near a magnet. That a region of that kind, where there appears a break in the continuity of the magnet's attractive and directive force, exists, I have no doubt; but I cannot agree with those who have declared for the existence of a line, or plane, of neutrality in the sense in which Mr. Gary and others have put it. Indeed one hundred and twenty years ago a neutral line was discovered by the celebrated John Robison, Professor of Natural Philosophy in the University of Edinburgh. He is the man of whom James Watt said, "He has the clearest head of any man I know." Having such good indorsement for clearness of head, I cannot do better than let him describe his own experiments:

"Amusing myself in the summer of 1758 with magnetic experiments, two large and strong magnets, A and B (Fig. 30), were placed with their dissimilar poles fronting each other and about three inches apart. A small needle, supported on a point, was placed between them at D, and it arranged itself in the same manner as the great magnets. Happening to set it off to a good distance on the table, as at F, I was surprised to see it immediately turn round on its pivot and arrange itself nearly in the opposite direction. Bringing it back to D, restored it to its former position. Carrying it gradually out along D F, perpendicular to N S, I observed it to become sensibly more feeble, vibrating more slowly; and when in a certain point, E, it had no polarity whatever toward A and B, but retained any position that was given it. Carrying it further out, it again acquired polarity to A and B, but in the opposite direction, for it now arranged itself in a position that was parallel to N S, but its north pole was next to N and its south pole to S.

"This singular appearance naturally excited my attention. The line on which the magnets, A and B, were placed had been marked on the table, as also the line, D F, perpendicular to the former. The point, E, was now marked as an important one. The experiments were interrupted by a friend coming in, to whom such things were no entertainment. Next day, wishing to repeat them to some friends, the magnets, A and B, were again laid on the line on which they had been placed the day before, and the needle was placed at E, expecting it to be neutral. But it was found to have a considerable verticity, turning its north pole toward the magnet, B, and it required to be taken further out, toward F, before it became neutral. While standing there, something chanced to joggle the magnets, A and B, and they instantly rushed together. At the same instant the little magnet, or needle, turned itself briskly, and arranged itself, as it had done the day before, at F, quivering very briskly, and thus showing great verticity. This naturally surprised the beholders; and we now found that by gradually withdrawing the magnets, A and B, from each other, the needle became weaker, then became neutral, and then turned round on its pivot and took the contrary position. It was very amusing to observe how the simply separating the magnets, A and B, or bringing them together, made the needle assume such a variety of positions and degrees of vivacity in each.

"The needle was now put in various situations, in respect to the two great magnets, namely, off at a side and not in the perpendicular, D F. In these situations it took an inconceivable variety of positions which could not be reduced to any rule: and, in most of them, it required only a motion of one of the great magnets for an inch or two, to make the needle turn briskly round on its pivot, and assume a position nearly opposite to what it had before.

"But all this was very puzzling, and it was not till after several months that the writer of this article, having conceived the notion of the magnetic curves, was in a condition to explain the phenomena. With this assistance, however, they are very clear and very instructive.

"Nothing hinders us from supposing the magnets, A and B, perfectly equal in every respect. Let N H M, N E L, be two magnetic curves belonging to A; that is, such that the needle arranges itself along the tangent of the curve. Then the magnet, B, has two curves, S G K, S E Q, perfectly equal and similar to the other two. Let the curves, N H M and S G K, intersect in C and F. Let the curves, N E L and S E Q, touch each other in E.

"The needle being placed at C would arrange itself in the tangent of the curve, K G S, by the action of B alone, having its north pole turned toward the south pole, S of B. But by the action of A alone it would be a tangent to the curve, N H M, having its north pole turned away from N. Therefore, by the combined actions of both magnets, it will take neither of these positions, but an intermediate one, nearly bisecting the angle formed by the two curves, having its north pole turned toward B.

"But remove the needle to F. Then, by the action of the magnet, A, it would be tangent to the curve, F M, having its north pole toward M. By the action of B, it would be a tangent to the curve, K F G, having its north pole in the angle, M F G, or turned toward A. By this joint action, it takes a position nearly bisecting the angle, G F M, with its north pole toward A.

"Let the needle be placed in E. Then, by the action of the magnet, A, it would be a tangent to the curve, N E L, with its north pole pointing to F. But, by the action of B, it will be a tangent to S E Q, with its north pole pointing to D. These actions being supposed equal and opposite, it will have no verticity, or will be neutral, and retain any position that is given to it.

"The curve, S E Q, intersects the curve, N H M, in P and Q. The same reasoning shows that when the needle is placed at P, it will arrange itself with its north pole in the angle, S P H; but, when taken to Q, it will stand with its north pole in the angle, E Q M.

"From these facts and reasonings we must infer that, for every distance of the magnets, A and B, there will be a series

of curves, to which the indefinitely short needle will always be a tangent. They will rise from the adjoining poles on both sides, crossing diagonally the lozenges formed by the *primary or simple curves*, as shown in Fig. 30. These may be called *compound or secondary* magnetic curves. Moreover, these secondary curves will be of two kinds, according as they pass through the first or second intersections of the primary curves, and the needle will have opposite positions when placed on them. These two sets of curves will be separated by a curve, G E H, in the circumference of which the needle will be neutral. This curve passes through the points where the primary curves touch each other. We may call this *the line of neutrality* or inactivity.

"We now see distinctly the effect of bringing the magnets, A and B, nearer together, or separating them farther from each other. By bringing them nearer to each other, the point, E, which is now a point of neutrality, may be found in the *second* intersection (such as F) of two magnetic curves, and the needle will take a subcontrary position. By drawing them farther from each other, E may be in the *first* intersection of two magnetic curves, and the needle will take a position similar to that of C.

"If the magnets, A and B, are not placed so as to form a straight line with their four poles, but have their axes making an angle with each other, the contacts and intersections of their attending curves may be very different from those now represented; and the positions of the needle will differ accordingly. But it is plain, from what has been said, that if we knew the law of action, and consequently the form of the primary curves, we should always be able to say what will be the position of the needle. Indeed, the consideration of the simple curves, although it was the means of suggesting to the writer of this article the explanation of those more complicated phenomena, is by no means necessary for this purpose. Having the law of magnetic action, we must know each of the eight forces by which the needle is affected, both in respect of direction and intensity, and therefore able to ascertain the single force arising from their composition.

"When the similar poles of A and B are opposed to each other, it is easy to see that the position of the needle must be extremely different from what we have been describing. When placed anywhere in the line, D F, between two magnets whose north poles front each other in N and S, its north pole will always point away from the middle point, D. There will be no neutral point, E. If the needle be placed at P or Q, its north pole will be within the angle, E P H, or F Q I. This position of the magnets gives another set of secondary curves, which also cross the primary curves, passing diagonally through the lozenges formed by their intersection. But it is the other diagonal of each lozenge which is a chord to those secondary curves. They will, therefore, have a form totally different from the former species.

"The consideration of this compounded magnetism is important in the science, both for explaining complex phenomena, and for advancing our knowledge of the great desideratum, the law of magnetic action.

(To be continued.)

MANUFACTURE OF CHLORIDE OF LIME.

THE WELDON PROCESS.

THIS process, which is carried out under the direction of M. Weldon, at the Chemical Works of Rossüen (Department of Les Bouches du Rhône), belonging to the General Chemical Manufacturing Company of the South of France, is based on the following reactions:

(1.) The decomposition of the chloride of manganese by lime, and the production of chloride of calcium and protoxide of manganese.

(2.) The peroxidation of the protoxide, produced by a current of air heated to 131° Fahr., and by an excess of lime. Instead of heating the air, the liquid holding the protoxide of manganese in suspension is heated.

In order to render our description intelligible to those who are unfamiliar with this class of manufacture, it may be well to give a brief sketch of the old process of manufacturing chloride of lime.

The process consists in half filling a number of large square pans of earthenware ("pierre de Volvic") with binoxide of manganese (manganese ore) from France, Spain, or Italy. A slab of the same material as the pan is placed on the top of each, and is luted down with clay; a quantity of hydrochloric acid, in the proportion of 97 lb. of acid to every 22 lb. of the manganese, is then poured in through a hole made for the purpose in the cover. The manganese rests on a double bottom, through which passes a leaden tube fitted into another pipe made of earthenware not liable to be acted on by acids, the purpose of the leaden pipe being to conduct the steam that is used to heat and to agitate the mixture.

The result of the reaction which thus takes place is to produce an evolution of chlorine which passes through a long pipe and into a second closed vessel, in which the gas is cooled and freed from the acid and aqueous vapor that it has absorbed; it thence passes into a vessel containing slaked lime, in order to form chloride of lime. The residue, produced by the action of the hydrochloric acid on the manganese, consists of a mixture of the chlorides of manganese, iron, and various other metals contained in the manganese ore, with a small proportion of free hydrochloric acid.

This liquid residue, which was formerly thrown away as useless, is now collected for the purpose of extracting the manganese and converting it into binoxide.

In order to effect this, the liquid is first of all neutralized by means of powdered chalk or limestone. An excess of either of these substances—that is to say, more than the equivalent necessary to saturate the quantity of free acid and of the foreign metals—is employed

This operation is conducted in wide wells or tanks constructed of masonry and sunk in the ground, and which are carefully luted. In the middle of each of these tanks a mechanical stirrer is made to rotate.

As soon as the liquid is completely neutralized, it is drawn off by means of a pump, which raises it to a height of about 50 feet, and transfers it to large depositing tanks of sheet-iron, where it is allowed to become clear. When it has so far settled as to leave from 12 to 16 inches of clear supernatant liquid above the deposit, it is drawn off by means of India-rubber siphons provided with branches for variable aspiration, the length of which is sufficient to enable the liquid to be drawn off to the bottom.

The clear liquid, which is a solution of chloride of manganese, is free from the chlorides of iron, alumina, etc., but contains chloride of calcium, which latter, however, is useful for producing the reaction that is to be produced. It is poured into large vats of thick sheet-iron, called "oxidizers," about 33 feet high and 11 feet 6 inches in diameter.

When all the chloride of manganese has become united in the oxidizers, the height of the liquid is carefully noted, and in a small testing apparatus, placed on a level with the bottom of the oxidizer, the metallic manganese contained in a cubic meter of the solution is estimated by means of a standard solution of permanganate of potash. This assay or estimation is very quickly effected; the standard solution is made so that one cubic centimeter corresponds with 0·01 gramme of metallic manganese. A burette containing 30 cubic centimeters, and divided into tenths of cubic centimeters, is filled with the standard solution, and 10 cubic centimeters of the solution to be assayed are poured into a matrass or flask, and 300 cubic centimeters of water added; the contents of the flask are then heated to between 175° to 195° Fahr., and the standard solution is added drop by drop from the burette, the solution in the flask being stirred continually; the precipitate of binoxide of manganese which is formed is allowed to settle from time to time, in order to enable the color of the supernatant liquid to be observed. As soon as the latter has assumed a pale rose tint, the operation is discontinued, and the number of divisions marked by the burette gives by calculation the quantity of metallic manganese contained in a cubic meter of the chloride of manganese solution in the oxidizer.

When the amount of manganese in the solution has been ascertained, steam is injected into the oxidizer by means of a pipe, in order to heat the solution to about 140° Fahr. While this heating process is going on, lime—in the state of "milk of lime"—is introduced into the oxidizer.

The preparation of the milk of lime is effected in vessels furnished with mechanical stirrers and with a strainer. The milk of lime thus formed during the operation of stirring is removed from the apparatus by means of a pump.

The further introduction of lime is stopped when a filtered portion of the liquid from the oxidizer no longer indicates the presence of free chloride of manganese. This test is repeated at short intervals, when one judges by experience that the required point has been reached. The experiment is very simple, and consists in introducing a few drops of a solution of chloride of lime into the filtered sample of liquid taken from the oxidizer. If this last contains any chloride of manganese, a precipitate of binoxide of manganese is formed, and if not, no change occurs in the solution.

Air is now injected into the bottom of the oxidizer by means of a perforated serpentine pipe. The liquid, which formed a pale rose-colored mud, now assumes a brownish gray color; an excess of milk of lime is added, corresponding to about six-tenths of the quantity added the first time. The oxidation rapidly increases and then decreases. The binoxide thus formed in the liquid in the oxidizer is measured from time to time, and when the quantity ceases sensibly to increase, a further quantity of chloride of manganese is added; this quantity should be about one-fifth of that which was added at first, and the injection of air is continued until the quantity of binoxide ceases to increase. The introduction of air is then stopped, and the whole of the liquid is poured from the oxidizer into depositing basins, at the bottom of which the binoxide settles. The color of this muddy deposit should be deep black, and never brown.

As soon as the deposit has settled to the bottom, the supernatant chloride of calcium is drawn off by means of the siphons already described, and is poured into the chlorine generators, which consist of large stone vessels strengthened by hoops and properly luted, and which are heated inside by means of a jet of steam. These generators or stills are furnished at their lower part with a pipe for the purpose of conducting the chlorine gas into chambers, in which about two inches of slaked lime in the form of dry powder is placed to the depth of about two inches, for the purpose of forming chloride of lime.

The operation in the oxidizers lasts about six hours; and while the process of oxidation is going on in one of them, the other is emptied and refilled.

As a certain waste of manganese always takes place in the different operations (this waste in the company's works amounting to from 4 to 6 per cent.), a generator is employed, in which an equal quantity of manganese is treated to compensate for the loss.

The following is the rationale of this regenerative process:

At the commencement of the manufacture of chlorine by means of maganese, it was discovered that the chloride of manganese resulting from that manufacture, when treated with lime, produces protoxide of maganese, which, by contact with air, becomes oxidized, forming sesquioxide of manganese, which latter, when treated with hydrochloric acid, is capable of producing chlorine gas. This sesquioxide, however, only produces one-third of the amount of chlorine that can be produced from the same quantity of acid by the binoxide. This process is consequently not a practical one; moreover, oxidation takes place very slowly.

The special merit of Weldon's process consists in turning to useful account what was formerly considered as waste product. The following is the way in which he surmounted the difficulty: The sesquioxide of manganese is known to be a combination of the protoxide with the binoxide ($MnO + MnO_2 = Mn_2O_3$).

Binoxide of manganese in the nascent state is capable of combining likewise with lime, which is a more powerful base than the protoxide. If, therefore, lime, held in suspension in water, be brought into contact with protoxide of manganese, and air be injected into the mixture, nearly the whole of the protoxide becomes converted into binoxide, which combines with the lime to form manganite of lime having the formula CaO,MnO_2. It is evident that if the operation were stopped at that point, the result would be the same as in the case of the sesquioxide; but it has been proved by experiments made by M. Weldon and by practice that if the manganite of lime thus formed be brought into contact with a solution of chloride of manganese, only one-half of the lime of the manganite combines with the chloride of manganese, and the following reaction takes place:

$$2\,(CaO,MnO_2) + MnCl = CaO,2MnO_2 + CaCl + MnO.$$

It will be easily seen that this compound $CaO_2,2MnO_2$ contains twice the amount of binoxide for the same quantity of base as the first. It may, therefore, be considered as a bimanganite of lime. Moreover, if air be injected into this mixture, the last equivalent of protoxide of manganese that is formed becomes converted into sesquioxide. Thus, six equivalents of chloride of manganese converted into sesquioxide would only give three equivalents of binoxide, according to the formula $6MnO + 3O = 3(Mn_2O_3) = 3MnO + 3\,MnO_2$, treated as above described, according to the following formula:

$$2(CaO,2MnO_2) + 2Mn_2O_3 = 2CaO + MnO + 5MnO_2.$$

Thus, five sixths of the manganese employed is recovered by this process, and—by employing an exact equivalent of lime in excess—it would be possible to recover the whole of that metal, but in that case, the mass in the oxidizers is liable to solidify; besides, the excess of base increases the consumption of acid. The following are the advantages of this process:

1. The cost of the recovered manganese, including all expenses, is 25 per cent. less than natural manganese at the same price.

2. The whole of the operations being conducted mechanically, a saving of 50 per cent. is effected in manual labor, but with a greater consumption of coal and acid.

3. The residue which runs into the drains is inoffensive, being only in the form of a weak solution of chloride of calcium.

It may be added, that by this process the chloride of lime only costs the company on an average 12s., instead of 16s. or 17s., per 100 kilogrammes (220 lb.)

EFFECT OF WATER AND DIFFERENT SOLUTIONS ON METALS.

THE results of a series of interesting experiments by Professor A. Wagner upon the action of water and different solutions, in connection with air and carbonic acid upon different metals and alloys, have been published. The metals were: sheet zinc with 08 per cent. of lead, commercial sheet-lead, pure melted and hammered tin, britannia metal, consisting of 90 per cent. tin and 10 per cent. antimony, brass of 64·5 per cent. copper and 35·5 per cent. zinc, German silver of 70·2 per cent. copper and 29·8 per cent. zinc and nickel. Portions of these, each presenting 11·831 square centimeters of surface, were immersed completely in 100 cubic centimeters of the different liquids, in one series of experiments, with the addition, for a week, of air free from carbonic acid, and in another series of experiments of air and carbonic acid. The solutions employed consisted of 0·5 gramme of potassium or sodium chloride, 1 gramme of ammonium chloride, 0·83 gramme of magnesium chloride, 1 gramme of potassium sulphate, 1 gramme of potassium nitrate, 1 gramme of sodium carbonate, and 0·923 gramme of sodium hydrate, each in 100 cubic centimeters of water and of lime water. Copper, in the first series of experiments—with air free from carbonic acid, lost in weight, in milligrammes, 904 in the ammonium chloride solution, but 5 in the magnesium chloride, 4 in the chlorides of the alkalies, 1 in distilled water, and nothing in the other solutions or in lime water. A considerable amount of copper was dissolved by the action of the ammonium chloride, and a trace by distilled water, and none by the other liquids. In the second series of experiments—with the addition of air and carbonic acid, the copper was attacked by all the solutions, losing 138 milligrammes in the ammonium chloride, only one-sixth as much as without the carbonic acid. 115 in the chlorides of the alkalies, 112 in magnesium chloride, 4 in potassium sulphate, 3 in potassium nitrate, and 3 in distilled water, and in all cases decided amounts of soluble compounds of the metal were formed. Zinc, in the first series of experiments, was attacked by all the solutions, losing 60 milligrammes in the caustic soda, 51 in ammonium chloride, 30 in potassium sulphate, 18 in magnesium chloride, 14 in distilled water, 9 in potassium nitrate, 7 in the alkaline chlorides, and 3 in lime water. Decided quantities of soluble zinc compounds were formed in the caustic soda, ammonium chloride and magnesium chloride solutions, but only traces in distilled water and lime water, and none in the other liquids. In the second series it was attacked by all the solutions, with a loss of 54 milligrammes in magnesium chloride, 53 in potassium sulphate, 38 in alkaline chlorides, 37 in potassium nitrate, 36 in ammonium chloride, and 19 in distilled water, and in all cases decided amounts of zinc passed into solution. All observations upon the effect of distilled water upon lead are without value for comparison, unless the presence or absence of air and carbonic acid is carefully noted. By the addition of air, free from carbonic acid, a precipitate is principally formed, and only traces pass into solution, but with the addition of carbonic acid considerable amounts pass into solution, the action being nearly three times as great as with air alone. In the solution of the alkaline chlorides, in the first series of experiments, the precipitate formed was seven times as great as that with distilled water, but no traces of lead could be detected in solution by means of sulphureted hydrogen; but in the second series, although the action seemed scarcely more than half as great as in the first, a large amount of lead was found in solution. The potassium sulphate was without effect upon its weight, and not a trace of lead could be detected in solution. With potassium nitrate, in the first series, the effect was less than with the alkaline chlorides, and no lead was dissolved, but with the addition of carbonic acid the action was more energetic, and considerable amounts passed into solution. In dilute carbonate of soda solution it remained unchanged, but dilute caustic soda attacked it energetically, no precipitate being formed, but a large amount of lead was dissolved. In lime water it required a coating of a reddish yellow precipitate. Tin lost, in the first series of experiments, 220 milligrammes in caustic soda, 7 in sodium carbonate, 6 in alkaline chlorides, 5 in ammonium chloride, 3 in potassium nitrate, 5 in potassium sulphate, 1 in magnesium chloride, and nothing in distilled or lime water, and only the caustic soda and sodium carbonate dissolved noticeable quantities of the metal. Addition of air and carbonic acid totally prevented action, except that there was a loss of 1 milligramme, in the potassium nitrate solution. Britannia metal lost, in the first series of experiments, 94 milligrammes in caustic soda, 9 in alkaline chlorides, 6 in sodium carbonate, 3 in ammonium chloride, 1 each in potassium sulphate and nitrate and magnesium chloride, and nothing in distilled or lime water. Caustic soda and sodium carbonate alone dissolved noticeable amounts of metal. On the addition of air and carbonic acid, the action of distilled water, ammonium chloride, and potassium sulphate was totally prevented, and only 1 milligramme was lost in the alkaline chlorides, magnesium chloride, and potassium nitrate, a discoverable amount of metal only passing into solution with the latter. Brass lost, in the first series of experiments, 269 milligrammes in ammonium chloride, 4 in magnesium chloride, and 2 each in alkaline chlorides, caustic soda, and lime water, and nothing in the other solutions or distilled water. Decided amounts of metal passed into solution in ammonium and magnesium chlorides, and traces in caustic soda and lime water. In the second series of experiments, the loss was 167 milligrammes in ammonium chloride, 92 in magnesium chloride, 80 in alkaline chlorides, 4 each in distilled water and potassium carbonate, and 3 in potassium nitrate; and by all decided amounts of metal were dissolved. German silver deported itself like brass, but was throughout less affected than brass.